DECEMBER 12, 1960
Published every-other-Monday
Seventy-five cents

Chemical Engineering

A McGRAW-HILL PUBLICATION

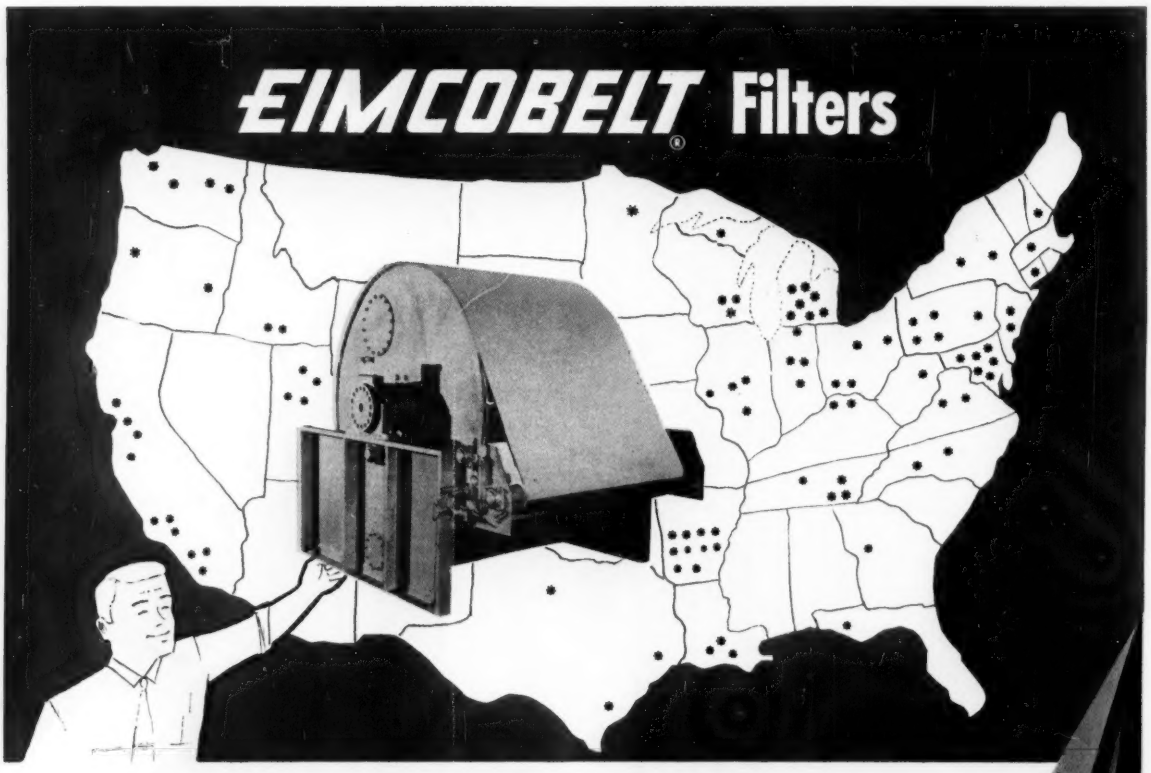
COMPARING IMPORTANT ROUTES TO

COMMERCIAL HYDROGEN

PAGE 161

FROM CONFERENCE ON CHEMICAL ENGINEERING

EIMCOBELT® Filters



Profitable for Processing Industries!

In all these installations, and in others throughout the world, EimcoBelt filters have reduced processing costs and set new performance records.

- In numerous installations, EimcoBelt filters have paid for themselves several times over, in increased product recovery . . . and in maintaining maximum rates.
- In several installations, EimcoBelt filters — because of their ability to handle slurries of low solids concentrations — have been able to eliminate the thickener and/or second stage filtration from the processing flowsheet.
- Wherever they've been installed, EimcoBelt filters have eliminated filter media blinding, thus greatly reducing downtime and maintenance.

EimcoBelt filters remove the filter medium from the drum continuously, for cake discharge and cloth washing. Because the medium is scoured clean, front and back, while it is away from the drum, finely-woven cloth or synthetic fabric media can be used — media that would blind at once on conventional drum filters.

Ask the Eimco representative in your area for facts on how EimcoBelt continuous belt filters can provide freedom from blinding in your operations — even handling difficult slurries that have never been filtered successfully on vacuum filters!

Write Eimco Filter Division for Bulletin F-2053.

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EIMCO

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SALT LAKE CITY, UTAH — U.S.A.

RESEARCH AND DEVELOPMENT CENTER
301 SO. HICKS ROAD, PALATINE, ILLINOIS

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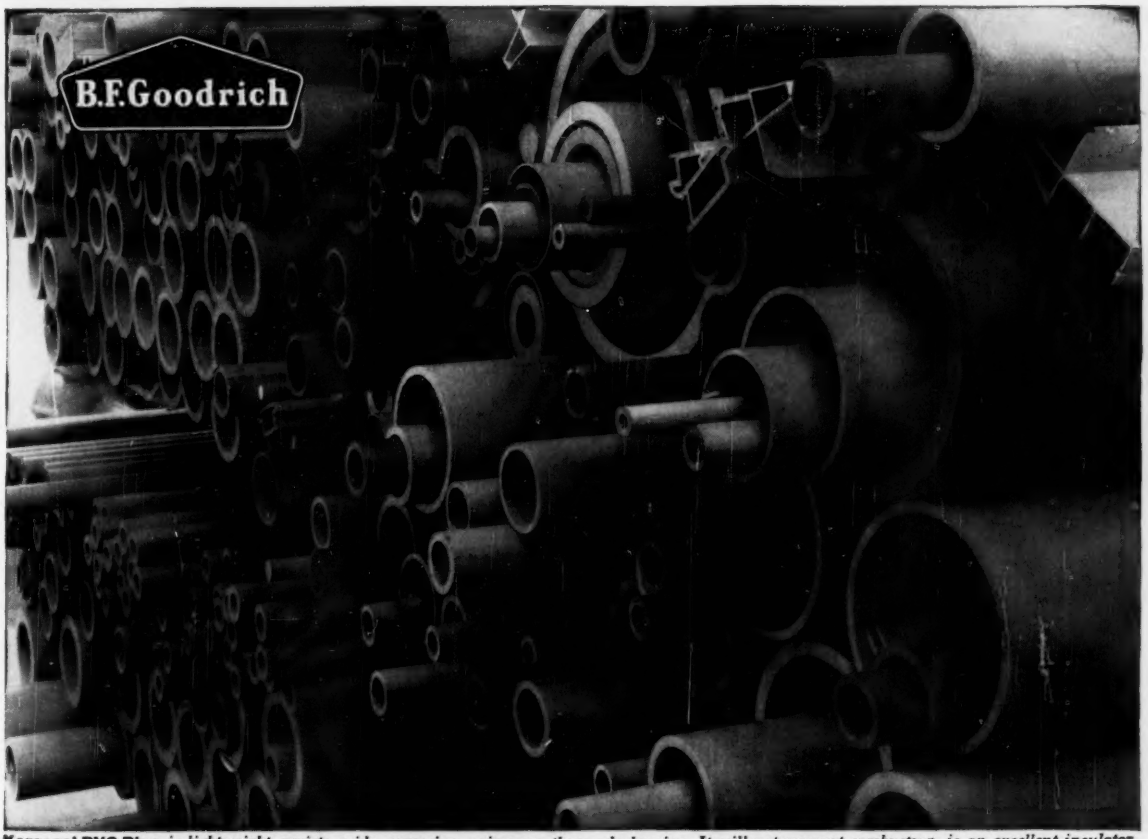

Koroseal PVC Pipe *is lightweight, resists acids, corrosion, aging, weather and abrasion. It will not support combustion, is an excellent insulator. Fast, easy installation and long life result in substantial cost reductions.*

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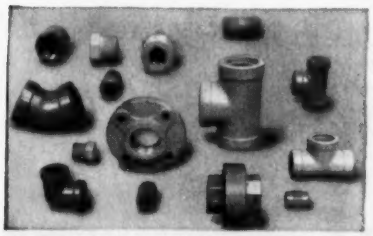
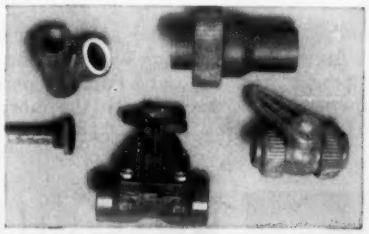
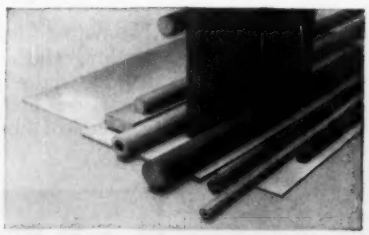
The more severe the service conditions, the more apparent are the superior properties and quality of rigid Koroseal PVC pipe, fittings, valves and sheet. Koroseal PVC is delivering long, trouble-free service in a multitude of industrial applications where corrosion, chemicals, high pressures and physical abuse ruined other types of pipe in a hurry. And savings are substantial—on original cost, installation costs, reduced maintenance and longer life. Investigate the many advantages of Koroseal PVC pipe now. For details, etc., write Dept. M937, *B.F.Goodrich Industrial Products Company, Marietta, Ohio.*



Koroseal PVC Fittings *can be joined to Koroseal pipe by solvent-cementing, heat welding, flanging or threading. Recessed threads protect against damage, eliminate cross threading. There's a size and type for every need.*



Koroseal Valves—*excellent for handling fluids, gases and corrosive materials. Complete selection of diaphragm, ball, and check valves for all types of service. Strainers and other piping components also available.*



Sheet, Tubing, Rods—*Koroseal PVC also is available in other forms . . . sheet and fabrication aids for duct work . . . bar stock for machined parts . . . tubing for special uses.*

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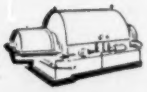
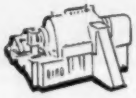
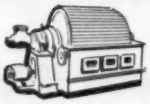
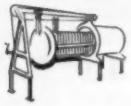
ARE YOU UNHAPPY
with your
Solid-Liquid Separations?

If so, put them to the test at the BIRD Research and Development Center Here it can be quickly and surely determined whether the job calls for a **continuous solid bowl centrifugal** (with wash if desired)  **continuous screen centrifugal** (and wash)  **drum type vacuum filter** (and wash)  **pan type vacuum filter with super-efficient wash** **oscillating screen centrifugal** **pressure filter**  or **batch centrifugal**

No matter what you're unhappy about — solids dryness, filtrate clarity, washing efficiency, fume-tight operation — *you* name it — chances are we have the equipment and the solid-liquid separation engineering knowledge and experience to come up with the most satisfactory and economical answer to the problem. Why not give it a try?

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Chemical Engineering

December 12, 1960

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

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VOLUME 67, NUMBER 25

Chemical Engineering (with Chemical & Metallurgical Engineering) is published biweekly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder.

Publication Office: 99-129 North Broadway, Albany 1, N. Y.

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Second class postage paid at Albany, N. Y. Printed in U.S.A. Title registered in U.S. Patent Office.
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Subscriptions: Send correspondence and change of address to Fulfillment Manager, Chemical Engineering, 330 West 42nd Street, New York 36, N. Y. Send notice promptly for change of address, giving old as well as new address. Enclose an address label from a recent issue of the magazine if possible. Allow one month for change to become effective.

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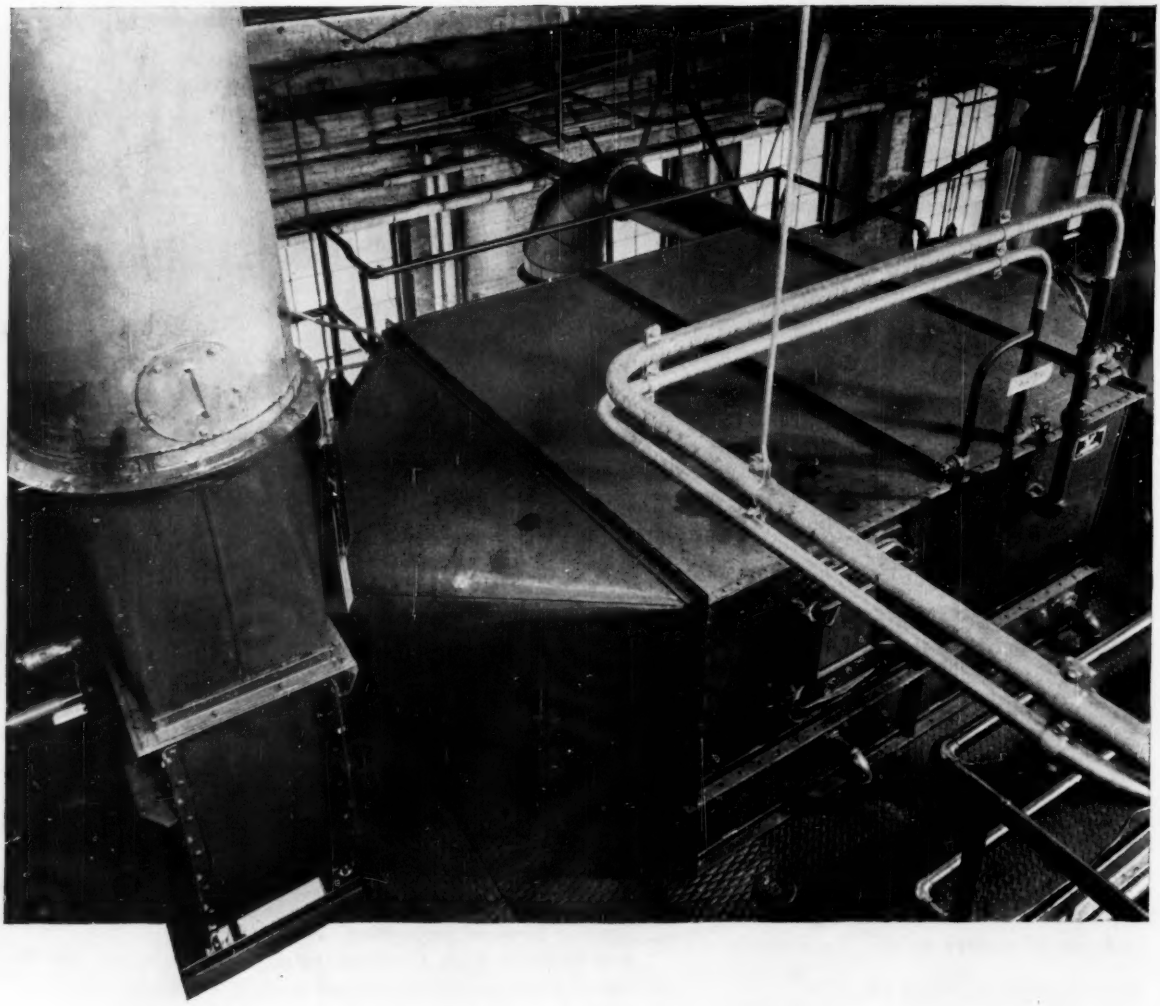

AIR POLLUTION PROBLEM?

'Buffalo' Gas Absorbers can remove entrained particulate matter from dryer vents, eliminate noxious gases from purge streams, scrub or absorb corrosive acid mists and fumes from vent systems, you name it—chances are a 'Buffalo' Gas Absorber can clean it up.

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Chemical Engineering
DECEMBER 12, 1960

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highlights of this issue

THE NEW CHEMICAL ENGINEERING

This title refers not to the magazine but to a series of articles beginning in this issue (p. 141) and continuing in three succeeding issues. This group of articles comprises the papers presented last month at our symposium in Kansas City, jointly sponsored with Midwest Research Institute.

As pointed out by keynoter Sid Kirkpatrick, the practice of chemical engineering has always reflected the progress made by the basic sciences of chemistry, physics and mathematics. But much has been happening in these basic sciences in recent years that most chemical engineers have not yet had the opportunity to learn and apply. Object of our symposium —both in speech and in print—is to help you toward better understanding and closer working relations with the sciences upon which our profession is based.

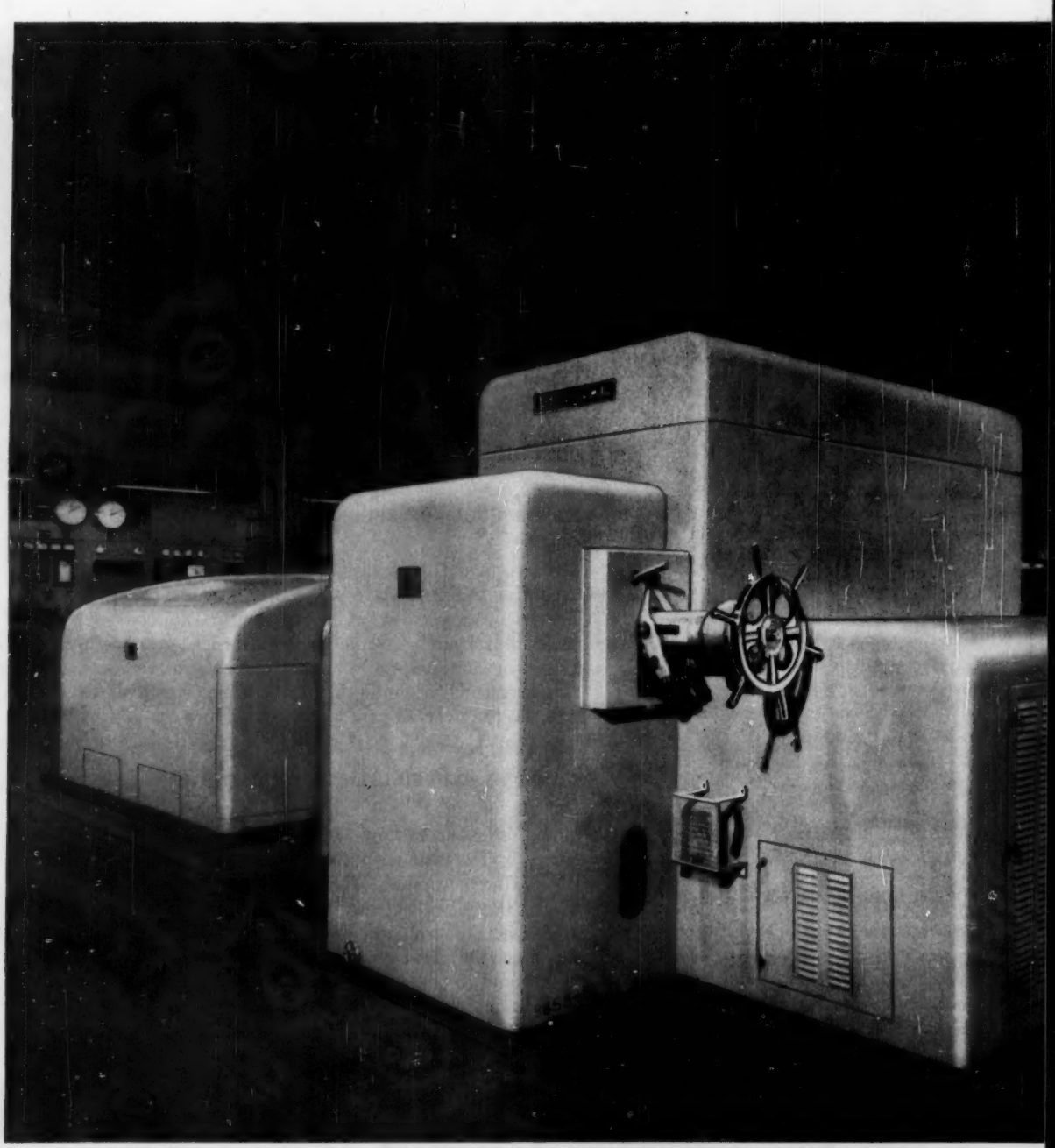
NEW SOURCES OF FLUORINE

Concern over future supplies of fluorine chemicals is stimulating a lot of activity today among chemical companies looking for economical ways to tap the fluorine content of low-grade fluorspar ores and phosphate rock. Assistant Editor Gene Guccione shows how development projects under way by American Cyanamid, Kaiser, Apache Chemical and others tie into the over-all raw materials picture (p. 79).

GUIDE TO REDUCING AGITATOR FAILURES

Our Corrosion Forum series on Corrosion-Control Design winds up the year with a down-to-earth treatment of design of mixing equipment for corrosive conditions. Author is Norm Parker, a chemical engineer of many years' experience with General American and Tower Iron Works. In this issue (p. 190), he covers such factors as splashing, corrosive solids and impeller location. Part 2, to appear in our next issue, will deal with more specific points, such as bolted vs. welded construction, bearing location and sealing devices.

DE LAVAL provides power and process steam

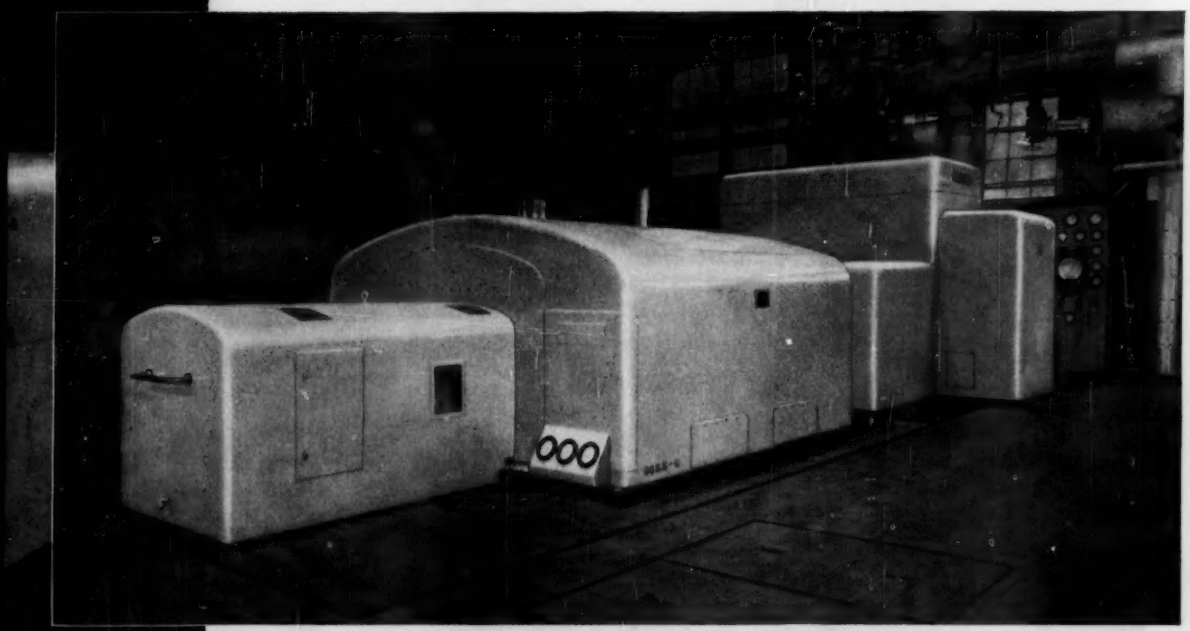


economical
for Corn Products Company

Sargent & Lundy, Consulting Engineers, handle project for new 9375 KW unit.

De Laval design engineers are specialists in meeting unusual requirements. For example, this unit at the Corn Products plant in Pekin, Illinois, is presently operating with 400 psig ISP at 580 F, with 6 stages to develop 5000 KW at a back pressure of 165 psig. Flexible De Laval design will enable this turbine to operate under new steam conditions with 11 stages for which space has been provided in the casing. When operating at its future steam conditions of 850 psig ISP, 700 F, the turbine will develop 9375 KW and will provide 275,000 pounds of steam per hour to the process at a pressure of 165 psig.

De Laval application engineers will gladly give you more information on steam turbines to suit your specific needs.



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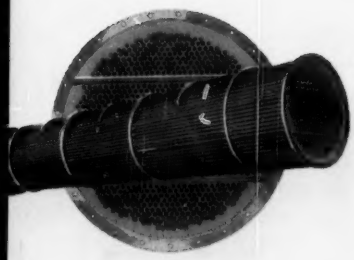

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FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!

MOVIE: "STOP LOSS WITH ORGANIZED LUBRICATION," a new 20-minute color-and-sound film that dramatizes the opportunities for cost control through Organized Lubrication.

INFORMATIVE FILM PACKAGE for plant departments consists of movies on greases, hydraulic oils, etc., designed to help those involved with their selection and application.

HERE ARE THE TOOLS THAT CAN HELP YOU

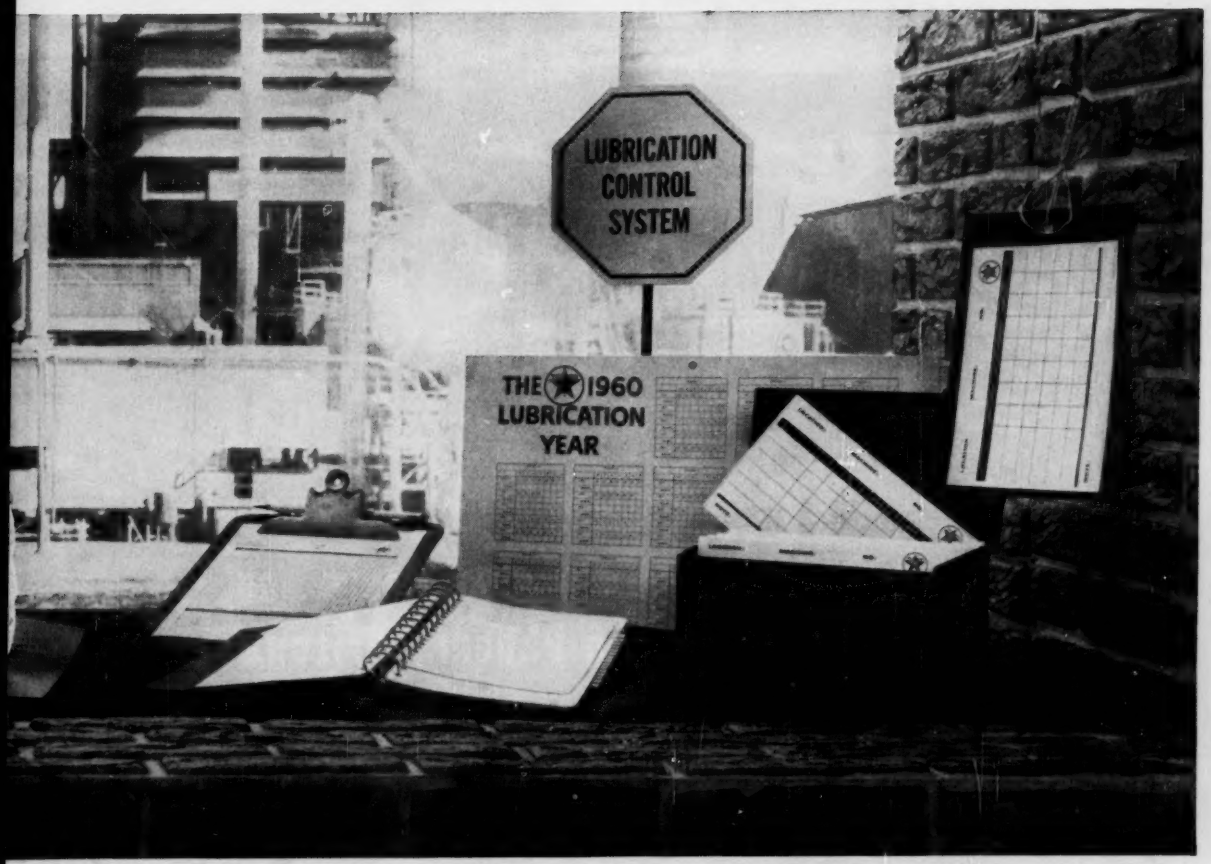
INCREASE YOUR NET PROFITS

Texaco's new "Stop Loss" program is designed to cut maintenance costs by modernizing lubrication practices. If yours is an average plant, the results can add 4 per cent to your net profit.

Even if your chemical processing plant is an efficient operation it is still virtually certain that there is an opportunity for cost control that you are overlooking—either partially or completely. This is in the vital area of lubrication. And nowhere are lubrication practices more critical than in the highly automated chemical processing industry.

The 4 per cent figure is not hypothetical. It's what the Small Business Administration has found the average plant can tack on to profits by organizing its lubrication.

Texaco's Program is designed to help you. Texaco has developed a "Stop Loss" Program specifically designed to help you cut maintenance costs via better lubrication practices. It will help you stretch equipment life, minimize downtime, reduce lube inventory, even cut purchasing costs. It costs virtually nothing to install; yet will start turning maintenance savings into profits almost immediately.



CO-ORDINATED BOOKLETS covering almost every facet of lubrication can be used as guides in specific areas.

TEXACO LUBRICATION CONTROL SYSTEM takes the guesswork out of all lubrication scheduling—makes sure that the right lubricant goes in the right place at the right time.

BY AS MUCH AS 4 PER CENT!

Can your plant pass this test?

Q. Is there anyone in your plant with the direct responsibility for all lubrication? Yes ☐ No ☐

Q. Is there any plant-wide system for making sure that equipment gets lubricated on schedule? Yes ☐ No ☐

Q. Are your oilers qualified men with a knowledge of mechanisms to be lubricated? Yes ☐ No ☐

Q. Have you had a lubrication study made to be sure you are using the proper lubricants at the right time? Yes ☐ No ☐

If the answer is "no" to any of the above questions, it is almost certain that a Texaco "Stop Loss" Program can improve your profit picture.

See for yourself how "Stop Loss" works! Texaco has just released a new color-and-sound movie to dramatize the benefits of good lubrication practices. It's called "Stop Loss through Organized Lubrication" and we think it would be profitable for you to see it. For an early showing in your plant, mail in the coupon today! Texaco Inc., 135 East 42nd Street, New York 17, N.Y.

MAKE YOUR RESERVATION TODAY!

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I would like to see your new movie "Stop Loss through Organized Lubrication." Please call to arrange a showing.

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These vast expansions of facilities, manpower and actual operating computer systems are the direct result of customer confidence in the General Electric Company Computer Department and the great expansion of the computer industry as a whole.

General Electric's competence in the computer field is the product of 40 years' experience. General Electric provides computing and information processing systems for business, industry, science, engineering, education and defense.

If you are considering the application of a computer to your firm's operation, contact the existing Computer Department sales office nearest you or write directly to:

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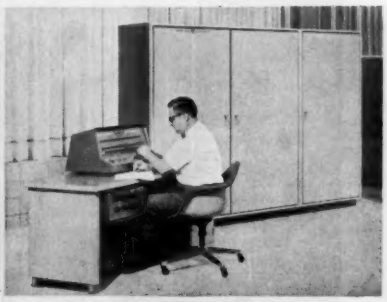
Nation's first MICR* Information Processing Center... with GE 210 computer system.

General Electric computers on test in modern manufacturing facilities.



GE-312 control computer now operating in various industrial applications.

*Magnetic Ink Character Recognition

Progress Is Our Most Important Product

GENERAL ELECTRIC

CPA36 (10-60)

See why ALCOA ALUMINUM makes good designs better

Requirement: achieve these major process equipment design aims: minimize product contamination . . . lengthen equipment life without adding maintenance costs . . . keep first cost down.

Key to Good Design: Alcoa Aluminum to eliminate contaminants, improve corrosion resistance, deliver strength without extra weight for design economies—at low first cost.

The evolution of process equipment design has developed a significant trend toward the use of aluminum—Alcoa® Aluminum—to satisfy increasingly stringent requirements of modern processing. At the base of this trend has been one factor: a growing awareness that aluminum provides a combination of chemical and physical properties perfectly suited to the needs of a particular process and the equipment which contains it.

Take, for example, the needs of a low pressure polyethylene process such as the one diagrammed below. The primary need here is for equipment which will not impart contaminants which discolor the product. The obvious design answer is aluminum with its demonstrated ability to prevent such contamination. Add to this such other important aluminum design benefits as these:

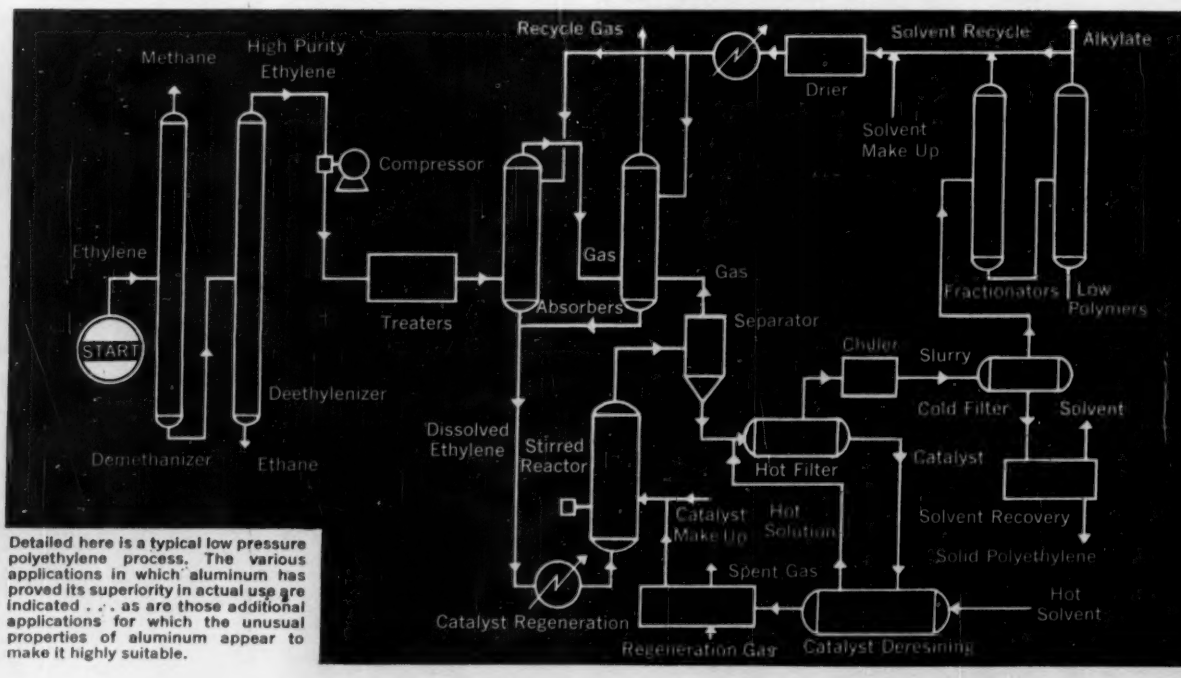
It provides a level of corrosion resistance unique among commonly used metals; its low temperature properties are outstanding (tensile and yield strengths actually increase without embrittlement as operating temperatures drop); it is nontoxic; its strength-weight ratio surpasses that of nearly every other metal; and its first cost is far lower than that of other suitable materials.

To take advantage of this unusual range of characteristics, designers and builders of polyolefin plants have employed Alcoa Aluminum in such varied equipment applications as heat exchangers, dryers, cyclone bins, cube storage bins, piping and a host of others.

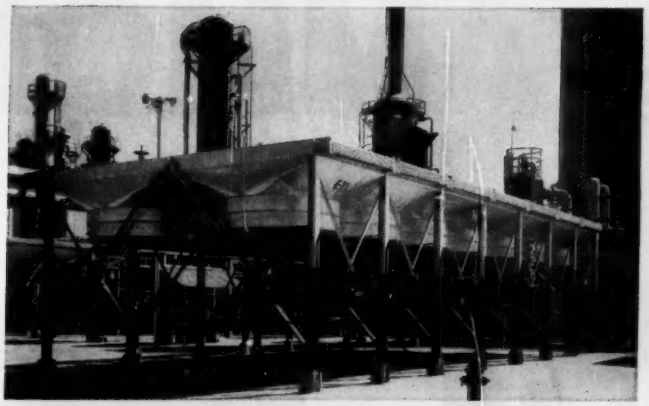
And polyethylene represents just one of literally hundreds of processes in which aluminum provides important design benefits on equipment applications of nearly every type. A few of these are shown on the opposite page. In nearly every case, aluminum's benefits can be predicted with surprising accuracy—thanks to the large volume of factual service data developed by Alcoa in well over 40 years of applying aluminum to process equipment requirements. Alcoa engineers are anxious to share this experience with you. They are doing so through a series of engineering conferences being held this year in major cities throughout the country. Your local Alcoa sales office will furnish you with details.

Examine the large body of Alcoa technical literature which describes in detail the proven performance characteristics of aluminum in a variety of process industries uses. Simply fill in and mail the coupon opposite.

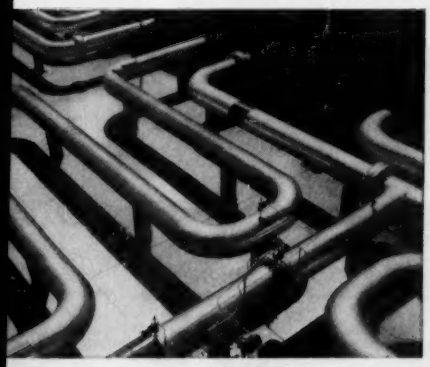
World-wide sales through ALCOA INTERNATIONAL, INC., 230 Park Avenue, New York 17, N.Y.



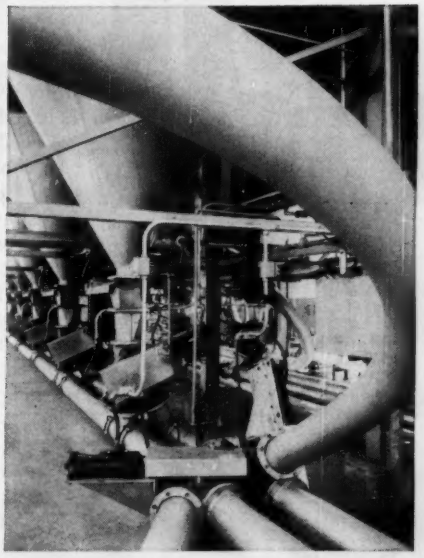
Detailed here is a typical low pressure polyethylene process. The various applications in which aluminum has proved its superiority in actual use are indicated . . . as are those additional applications for which the unusual properties of aluminum appear to make it highly suitable.



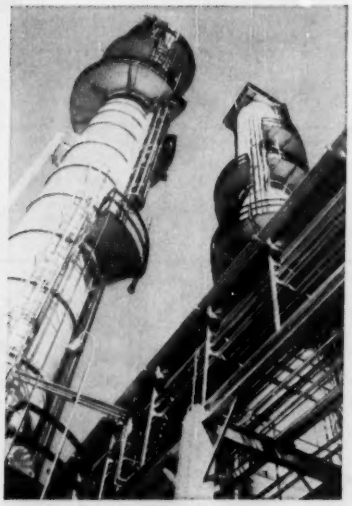
Below, aluminum's ability to maintain its serviceability and excellent appearance in chemically contaminated atmospheres is utilized here in Al-Cor-Jac alclad aluminum jacketing—manufactured by Insul-Coustic Corporation, Maspeth, Long Island, N.Y.



Pictured above is a Solo-aire cooling unit manufactured by Hudson Engineering Corporation, Houston, Texas. Here the excellent heat transfer properties of aluminum made it a] natural choice for process cooling. Of important added value are the excellent corrosion resistance of aluminum and its outstanding low temperature properties.



Right, this polyethylene process employs a variety of aluminum applications to prevent product discoloration. Since the process operates at extremely low temperatures, aluminum's excellent low temperature durability is an important asset in piping, bins, hoppers and vessels.



These prilling towers and nearly all of the piping and equipment surrounding them are aluminum. Selection of Alcoa Aluminum was based upon the metal's unique ability to withstand corrosive attack in this nitrogen fertilizer operation — plus its excellent strength-weight ratio which contributes to economical design by eliminating the need for excessive structural support.

For exciting drama watch "Alcoa Presents" every Tuesday—ABC-TV

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

Aluminum Company of America, 871-M Alcoa Building, Pittsburgh 19, Pa.

Please send me the following literature covering Alcoa Aluminum for tubular products and other uses in the process industries:

- ☐ 10197 Aluminum Pipe and Fittings
- ☐ 10418 Alcoa Unitrace: Combines Piping and Tracing in One Unit
- ☐ 514 Alcoa Duotrace Technical Report
- ☐ 10270 Alcoa Utilitube
- ☐ 10460 Process Industries Applications of Alcoa Aluminum
- ☐ 11453 Solving Refinery Corrosion Problems with Aluminum
- ☐ 20849 Resistance of Aluminum Alloys to Weathering and Resistance of Aluminum Alloys to Chemically Contaminated Atmospheres
- ☐ 20437 Aluminum Alloy Heat Exchangers in the Process Industries
- ☐ 19416 Brazing Alcoa Aluminum
- ☐ 19415 Welding Alcoa Aluminum
- ☐ 19051 Alcoa Aluminum Handbook

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Address.....

City.....Zone.....

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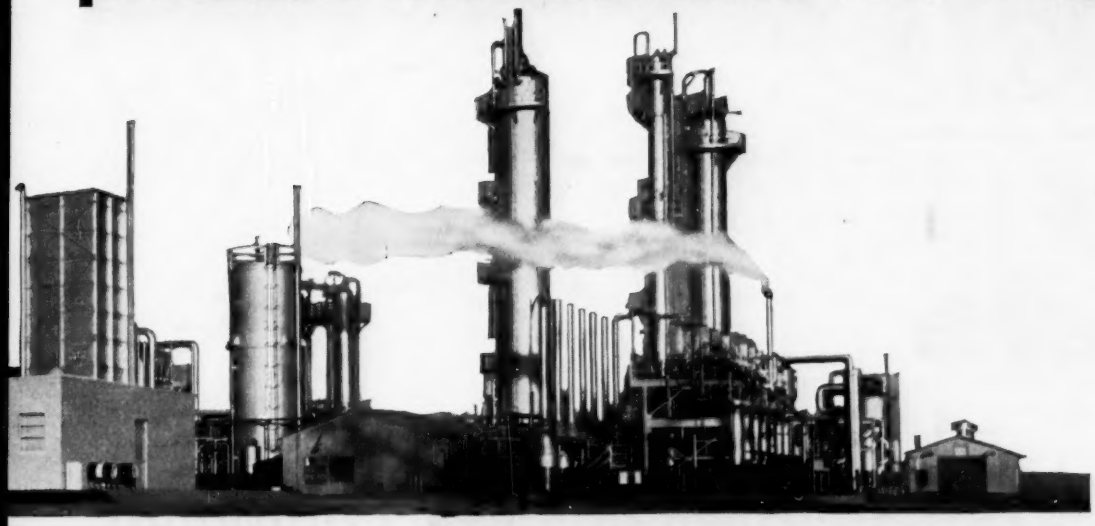
AMMONIA

FEED	NO. OF PLANTS	HYDROGEN PRODUCTION	NITROGEN SUPPLY	AMMONIA SYNTHESIS PROCESS	CAP. T/D	Location
BY-PRODUCT HYDROGEN	1	Oxygen Removal; NaOH Scrubber	Air Separation; N_2; Air; O_2	Casale	60	Michigan
ACETYLENE PLANT TAIL GAS	1	H_2O; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash	Air Separation; H_2; Air; O_2	Casale	110	Texas
HYDROGEN-RICH REFINERY OFF-GAS	2	H_2S Removal; CO_2 Removal; Low-temperature Methanation and Liquid Nitrogen Wash; N_2	Air Separation; N_2; Air; O_2	2 Casale	380 180	Louisiana Illinois
NATURAL GAS (a)	5	O_2; Texaco Partial Oxidation; H_2O; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash; O_2; N_2	Air Separation; N_2; Air; O_2	4 Casale 1 Other	210 (b) 230 300 180 100	Mississippi Oklahoma Tennessee Kansas Brazil
OIL	2	O_2; Stm; Texaco Partial Oxidation; H_2O; Carbon Removal; H_2O; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash; O_2; N_2	Air Separation; N_2; Air; O_2	2 Others	110 (b) 120 (b)	Japan Japan
OIL (HIGH SULFUR)	2	O_2; Stm; Texaco Partial Oxidation; H_2O; Carbon Removal; Sulfur Removal; H_2O; Shift Conversion; CO_2 Removal; Liquid Nitrogen Wash	Air Separation; N_2; Air; O_2	1 Other	360 (b) 330	Spain Italy
NATURAL GAS	2	Steam; Air; H_2O; H_2S Removal; Steam Reforming; 1st Stage Shift Conversion; CO_2 Removal; H_2O; 2nd Stage Shift Conversion; CO_2 Removal; Methanation	From Secondary Reforming	2 Casale	200 115	Indonesia Iran
TOTAL	15	(a) Purification before oxidation not normally required.	(b) Synthesis gas		3985	

process installations 1945-1960



Worldwide experience with six feeds utilizing seven process sequences to produce ammonia

More than one million tons per year ammonia capacity has been built or is under contract by Foster Wheeler. Eight Foster Wheeler plants account for 20% of the tremendous increase in the production of ammonia in the United States over the last decade. The table at left provides a brief view of FW's process flexibility and worldwide experience.

The most recently completed FW ammonia plant exceeded rated capacity within one month of start-up. Economic production over a wide range of outputs has been realized. From plants of modest size, to those in the higher capacity ranges, these Foster Wheeler ammonia plants turn in exceptional performances.

Foster Wheeler has also designed and constructed two of the largest urea plants in the United States. Both use the Pechiney-Grace process featuring total recycle and produce urea of superior quality and color. To get information on the ways Foster Wheeler process experience can serve you, write to Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.

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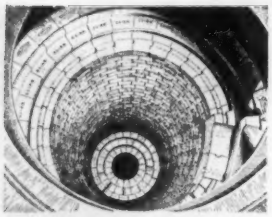
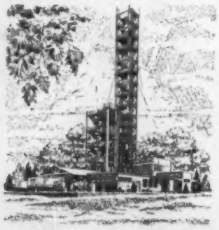
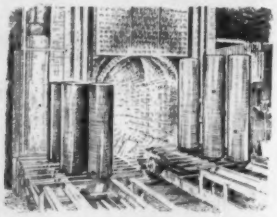


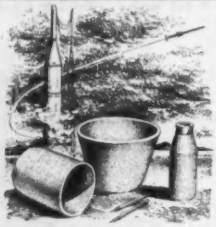
Pebble Heater Linings and Pebbles



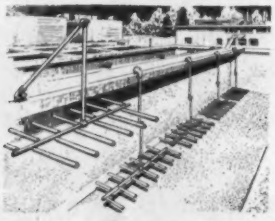
Chemical Reactor Linings



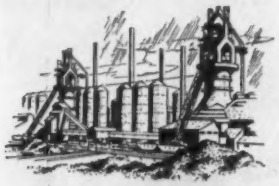
Muffle Plates and Kiln Shapes



Missile and Rocket Ceramics



Porous Media for Sewage Systems



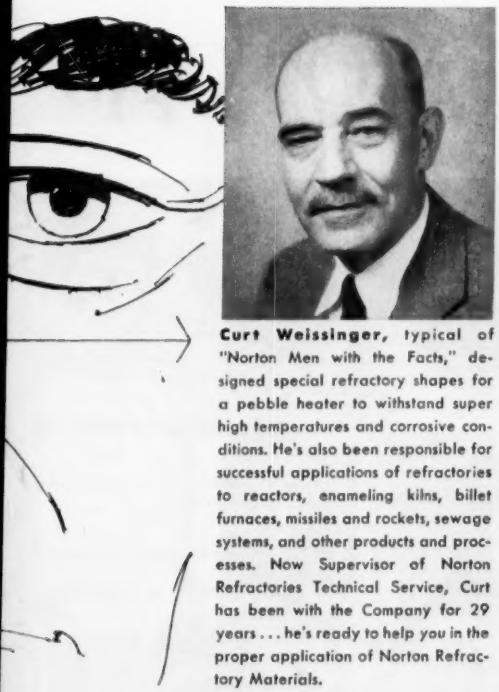
Wear Resistant Linings for sintering

Working with today's imaginative design engineers, Norton Company's "Men with the Facts" are creating exciting new concepts in products and processes. Utilizing the wide variety of physical, chemical and electrical properties of Norton Refractory Materials, they help to solve design problems in products ranging from lightning arrestors to rockets . . . in processes as different as filtration and gas synthesis.

Norton's "Man with the Facts" knows where his company's product can best be applied. Perhaps the high thermal conductivity and high refractoriness of CRYSTOLON* silicon carbide are needed . . . or the excellent chemical stability and abrasion resistance of ALUNDUM* aluminum oxide.

to solve your design problems . . .

NORTON Refractories and the NORTON Man



Curt Weissinger, typical of "Norton Men with the Facts," designed special refractory shapes for a pebble heater to withstand super high temperatures and corrosive conditions. He's also been responsible for successful applications of refractories to reactors, enameling kilns, billet furnaces, missiles and rockets, sewage systems, and other products and processes. Now Supervisor of Norton Refractories Technical Service, Curt has been with the Company for 29 years . . . he's ready to help you in the proper application of Norton Refractory Materials.

Often MAGNORITE* magnesium oxide solves a problem with its high purity and excellent thermal conduction and high electrical resistance. Or, the immunity to oxidation and reduction of zirconium oxide, one of today's highest melting point oxides available in tonnage quantities, may be invaluable.

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THE MAN & THE MOTORS

Mr. Westinghouse* and the Life-Line A motor brought 56,940 hours' continuous service in highly corrosive atmosphere to Allied Chemical's General Chemical Division

When General Chemical called in their Westinghouse sales engineer back in 1953, they had a serious drive problem. An electric motor was required for 24-hour service in an atmosphere containing hydrogen chloride, sulphur dioxide and sulphur trioxide. Ambient conditions varied from 70° to 100°F.

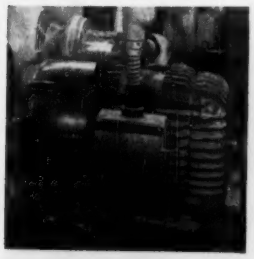
A Westinghouse Life-Line "A" Type TEFC motor was selected to power a screw conveyer that feeds raw material at the rate of seven tons every 24 hours, 365 days per year, from storage hoppers. A motor breakdown would result in a two-hour shutdown of the equipment it serves.

After more than 6½ years of 'round-the-clock operation, this Westinghouse Life-Line "A" motor is still giving trouble-free service under very severe operating conditions. Such a record indicates many more years of outstanding service.

Mr. Westinghouse is well equipped to step in and help you solve *your* drive problems . . . just as he did at General Chemical Corporation.

**Tom G. Broussard, Westinghouse Sales Engineer in Philadelphia*

FROM WESTINGHOUSE



Life-Line A motors and Mr. Westinghouse† team up to bring nonstop, 24-hour operation to sulphuric acid manufacturing for Rumford Chemical Works

Because of the damage caused to the windings of other motors by the highly corrosive atmosphere of sulphuric acid, Rumford Chemical had to rewind an average of two motors a year. Further, any shutdown for repairs not only stopped the process, but released an unbearable nuisance odor into surrounding residential neighborhoods.

The plant engineer of Rumford Chemical says: "In the 10 years we have been using Westinghouse Life-Line motors, we have never once stopped the process because of a faulty motor. Now we never have to rewind our motors because spilled acid can't reach the innards, nor do we have to worry about acid-contaminated lubricating oil or grease because the Westinghouse motors are prelubricated."

†*W. C. Russell, Providence, R. I., office*

Call in The Man from Westinghouse when you need help with your electrical drive or related control requirements. He's well equipped to supply motors from fractional hp to hundreds of "horses." With his experience in drive problems, backed by the industry's best research and development facilities, he'll show you how to save money . . . whether it's a shelf item or a custom-engineered job. For additional information write: Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania.

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YOU CAN BE SURE...IF IT'S Westinghouse

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MICRO-WYND
FILTER CARTRIDGE
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ACFC

You asked for a wound filter cartridge with superior performance characteristics . . . and here it is!

MICRO-WYND

. . . the outstanding depth-type, disposable filter cartridge

MICRO-WYND is Cuno's answer to the many operating headaches typical of the ordinary wound cartridge . . . because it is designed and built with absolute control of all elements affecting filtration performance.

MICRO-WYND's patented manufacturing process unites a layer of fibers of proven filter properties with a winding yarn of exceptional strength. The filter fibers, woven in and out of the winding yarn, are firmly locked in place, completely bridging each diamond-shaped fluid path. This exclusive Cuno process does away with problems of variable flow, early loading, sudden contaminant bypassing that users encounter with ordinary wound filters whose efficiency is compromised by a mere brushing of the winding yarn to raise filter fibers.

There's more to MICRO-WYND, too, than meets the eye. Graded density in depth, or ability to trap progressively finer particles from O.D. to core, is achieved by controlled dispersion of the separately applied layer of filter fibers. Strict control of winding yarn tension and method of application also gives you a cartridge that is structurally strong, that assembles in multiples without extra end sealing devices, and that stands up under the toughest operating conditions.

Get the facts *now* on MICRO-WYND . . . the all-new wound cartridge that's designed and built to set new filtration performance standards in your plant!

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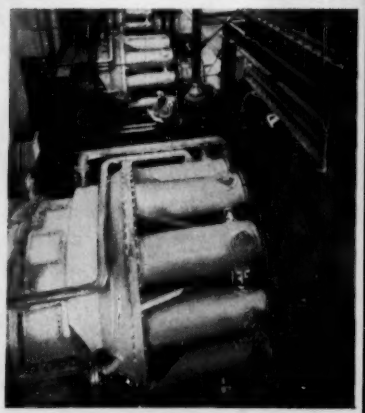

GAS TURBINES are especially appropriate for drive applications where hot exhaust gases from the turbines can be used for economical process hot air or steam.

General Electric Application Engineering Helps Put Your New Plant on Stream Faster

When fast-breaking product developments make additional plant facilities necessary, General Electric will help get your new product on stream fast. G. E. application engineers will assist you in quickly completing one of your biggest tasks—the selection of appropriate drive equipment for pumps, compressors, and blowers. In fact, General Electric will assume responsibility for recommending and supplying *all* your drive-system needs from its complete line of electric motors, gas turbines, steam turbines, and other system components.

WHEN, FOR EXAMPLE, EARLY SYSTEM STUDIES indicate the use of motors for a number of your applications, you still must make many decisions concerning each: horsepower, type, voltage, speed, enclosure, insulation system, gearing. General Electric application engineers will help you make the right decisions fast, offering co-ordinated delivery on the most appropriate G-E motors—from fractionals to 10,000 horsepower and above. Along with speed of selection and delivery, you get better performance because your quality G-E motors are precisely matched to their applications. Also, you get the economy benefits of single-source buying, with maximum standardization for spare-parts interchangeability.

FOR MORE COMPLETE INFORMATION on G-E application engineering that can help put your new plant on stream faster, call your local General Electric Sales Engineer, or write, General Electric Co., Schenectady 5, N. Y. 651-03

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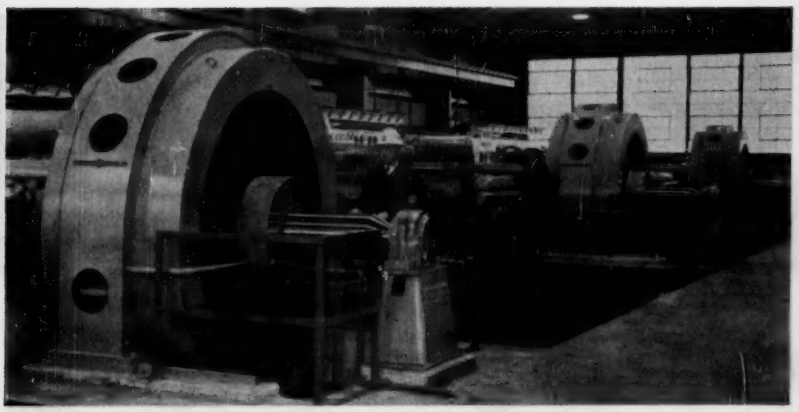
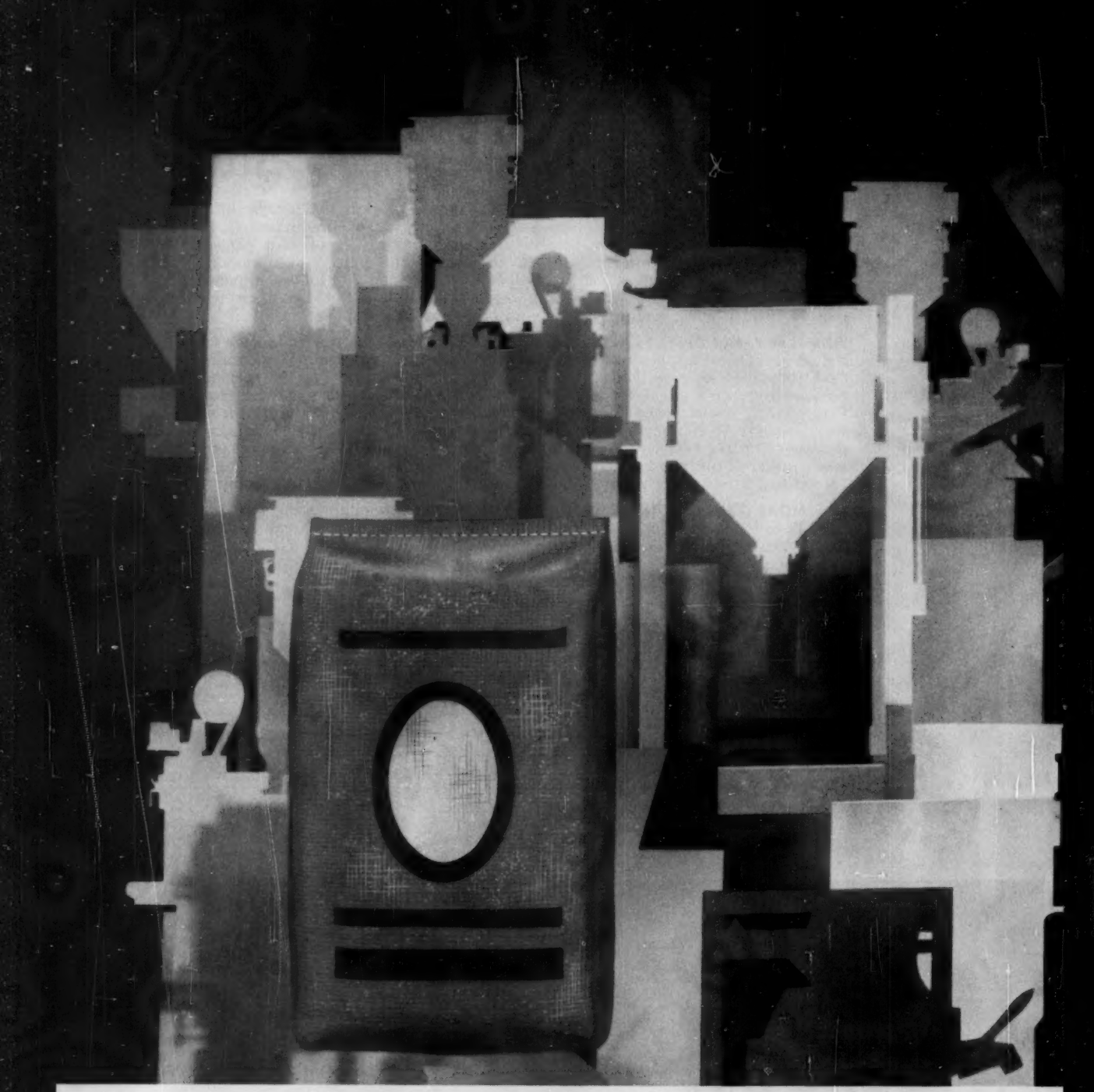


SYNCHRONOUS MOTORS for key compressor and blower applications will be built exactly to your requirements, drawing on more than 60 years of manufacturing experience. These motors, with improved insulation systems, operate reliably under many process conditions.

NEW TRUE MASS FLOWMETER—one of many other G-E products for the process industries—measures fluid flow directly in pounds, eliminates the costly conversion of volume to weight.

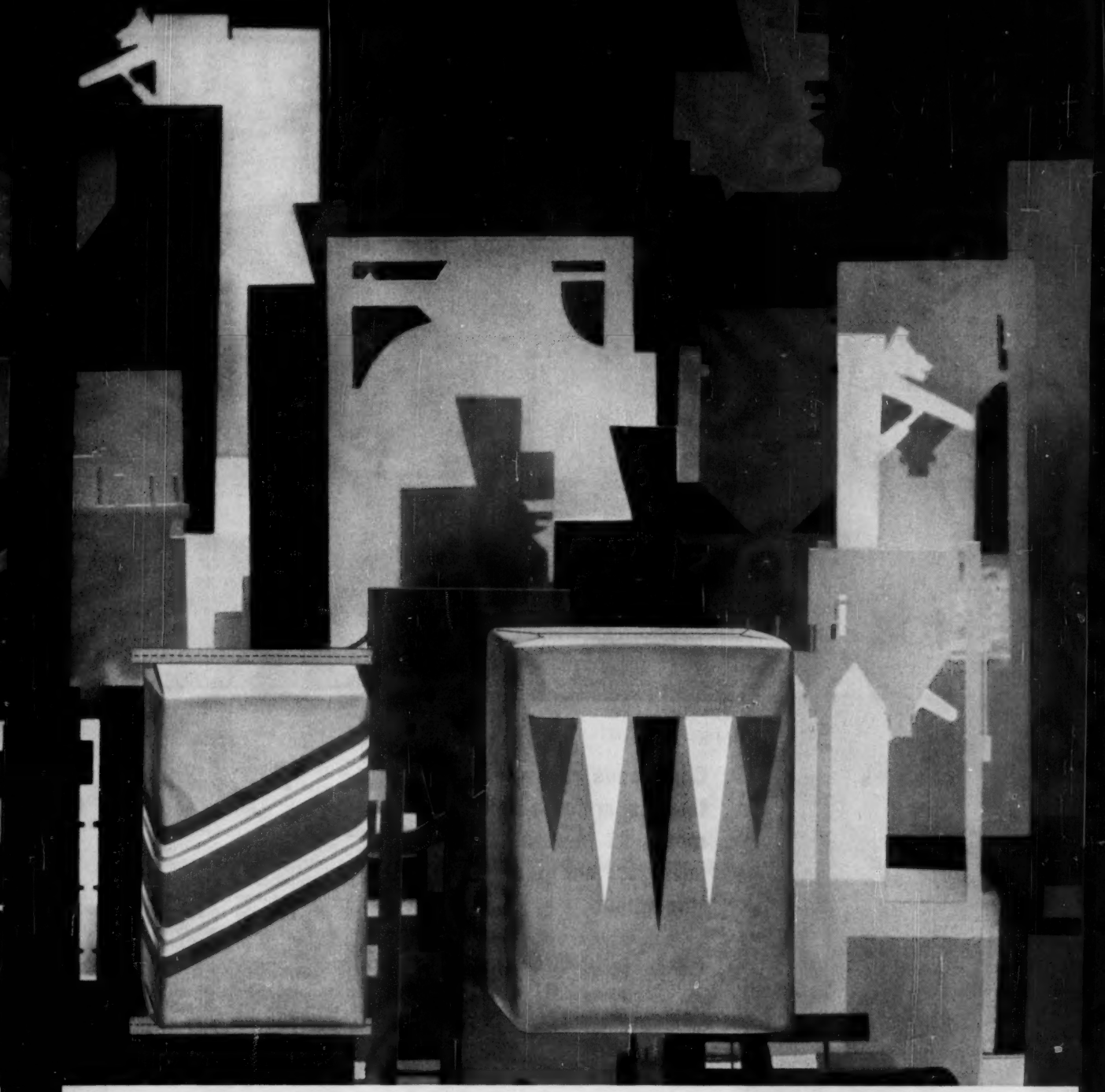


Profit-building packaging

Want the machine that will do the best and most economical job of packing your product? Only St. Regis® offers you a line of bag packing machinery over 50 models deep. That means you choose from the widest selection in the industry... you get the machine best suited to the job... a machine that does the work faster, more accurately and at the lowest cost.

A full line of machinery is only part of the most complete bag service ever offered—*Packaging-in-Depth.* This service gives you the benefits of a *complete* line of bags—multiwall, textile and WPPL. It includes St. Regis research that works for you, pioneering advances like the Force Flow,® Streamflow and Easiflow Packers and developing special protective papers such as Capcote PE for greater moisture protection at lower cost.

From 13 manufacturing plants and 34 sales offices



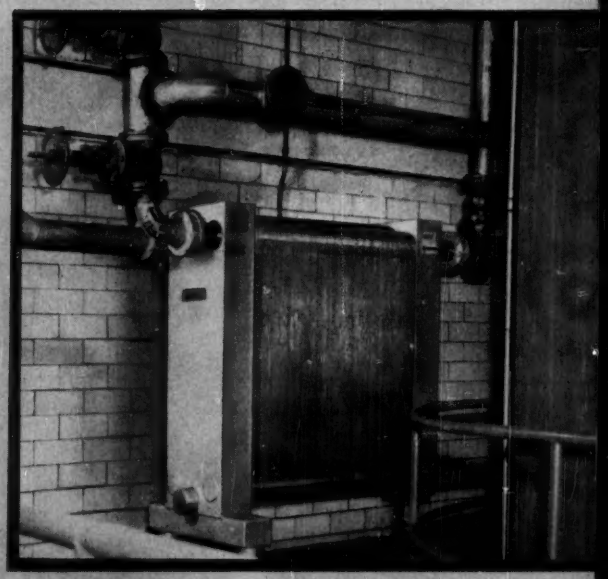
machinery...50 models deep

throughout the country, count on St. Regis for swifter delivery of the bags you want when and where you want them. All this is backed by the most complete staff of packaging engineers, field engineers and materials handling specialists in the industry.

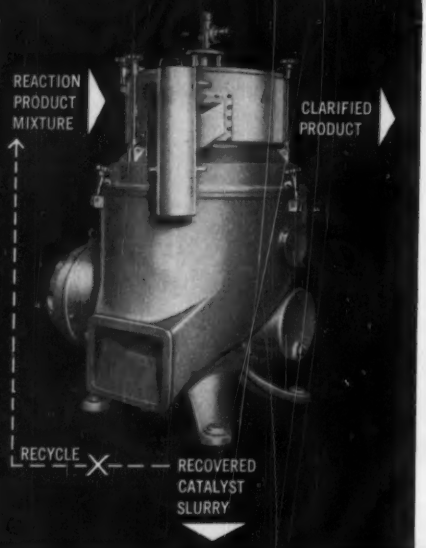
It all adds up to this: behind each St. Regis machine or bag you buy stands the most complete bag service available. This is St. Regis *Packaging-in-Depth!*

PACKAGING-IN-DEPTH BY St.Regis BAG DIVISION
PAPER COMPANY

De Laval tackles process problems



...economically!



Continuous recovery of fine dispersion as slurry meant $$ in catalyst saving... and greater throughput

Problem: An expensive catalyst remained finely dispersed in the heavier of a two-phase reaction mixture. Previous recovery attempts gave a hard cake of non-dispersible catalyst.

Solution: The catalyst was discharged continuously from the centrifuge bowl wall as a re-useable concentrated liquid slurry in a De Laval AC-VO "Nozzle-Matic" Centrifuge.

Control of the slurry concentration was easily effected by recirculation of a portion to the feed stream. An ideal concentrated, dispersed slurry was thus obtained, suitable for re-use. Savings come not only from the recovery of valuable catalyst, but also from faster, continuous throughput of the entire product stream.

"Haze" removal and the separation of thick slurries are the extremes in solid-liquid and solid-liquid-liquid centrifugal separation. De Laval is unmatched in equipment and experience in this entire range. Try us!

For Further Information Write To Dept. C-12A

DE LAVAL

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Poughkeepsie, New York
5724 N. Pulaski, Chicago 46, Illinois

DE LAVAL PACIFIC COMPANY, Dept.
201 E. Millbrae Avenue, Millbrae, Calif.

CENTRIFUGES
PLATE HEAT EXCHANGERS
VIBRATING SCREENS
COMPLETE PROCESSES

Remarkably small unit delivers 11,000,000 Btu/hr ...typifies new trend in heat exchanger selection

Every hour, 100,000 pounds of river feed water is heated from 40° to 150°F at Finch, Pruyn & Company, Glens Falls, N.Y. Waste sulfite liquor supplies the heat, and the exchange of 11,000,000 Btu hourly is done in a space 6'2" x 2'9" x 11'8"!

No other type of heat exchanger could have been put in this waste space. More important, the compact size makes stainless steel construction practical – a lifetime assurance of trouble-free operation. This application is typical of many in which De Laval Plate Heat Exchangers are replacing bulkier, less-efficient types.

An objective appraisal tells you why. Here are the up-to-date facts:

- De Laval Plate Heat Exchangers require only one-quarter the heat exchange surface of shell-and-tubes.
- This reduced exchange surface is arranged in a remarkably compact unit.
- With stainless-steel construction throughout, there is a "lifetime" pay-off in corrosion-free service.
- De Laval Plate Heat Exchangers clean in-place – or open quickly and easily for thorough scrubbing.
- Where needed, unusually stable temperature control is easily obtained.
- Sub-division of the exchange capacity – or expansion at any time – is easily effected by introducing additional heat transfer plates.

Collectively, these benefits add to a low *total* cost in installation and operation that has led to greatly broadened applications in recent years. Check, at no obligation, on the contributions their efficiency can make to your operation. De Laval Plate Heat Exchangers range in size from laboratory models to capacities of over 200,000 lbs./hr.

1960 ISN'T 1950...WHICH WASN'T 1940!

"Time creeps up—not only on us but also on the 'facts' we work with. Look squarely at the present and future in terms of unit design costs; labor and plant space have gone high—will go higher. Unlike 20 or even 10 years ago, installation of 'lowest cost' types of process equipment can seldom be justified. Real economy now lies more than ever in the savings of small-space, low-maintenance performance, minimum supervision and long life. A case in point is the growing use of De Laval stainless steel Plate Heat Exchangers such as the installation described above."

Fred Wheelwright, Industrial Sales Manager

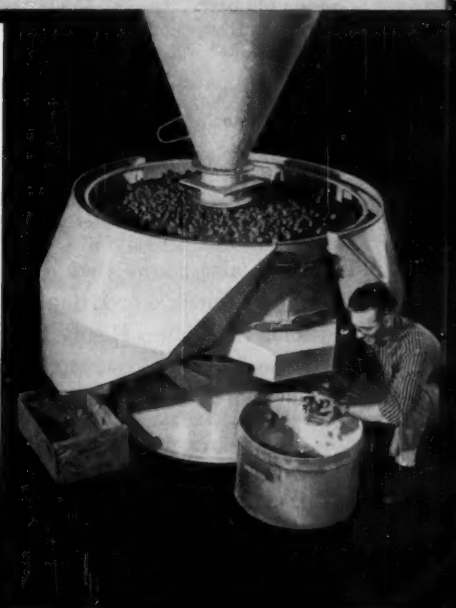
"3-D" winner in "shell game" also scores 95% in pearlite classification

Lumps, pellets, crystals or powders are kept hopping to a controlled frequency as they pass over or through De Laval's Syncro-Matic screen decks. Motion is fully "3-D" and is adjustable in each direction to suit the material and obtain the desired throughput and efficiency.

The result is unusually rapid and efficient classification. For example:

- A battery of six graders which separated walnuts to three standard sizes was down-grading 18 to 35% of them. A single De Laval Syncro-Matic Separator replaced all these machines and also reduced down-grading to under 1%! Throughput was 10,000 lbs./hr.
- Crushed pearlite ore required classification to four closely-defined grades. A single three-screen De Laval Syncro-Matic Separator processes 5 tons per hour to give better than 95% efficiencies in all four grades.

Maximum exposure of product to grading screens is provided in these Syncro-Matics. Available in single, double and triple screen decks, regular and stainless steel, they are certainly worth evaluating for both existing and planned classification installations. Write for information.



What you should know about the economics of Reynolds Aluminum Process Pipe

Reynolds Aluminum Process Pipe—strong, lightweight, and corrosion-resistant—costs no more than cold rolled black steel or galvanized steel pipe, when you consider the total installed cost. For example, the table below shows that the base price of Reynolds Aluminum Heavy-End Pipe is almost as low as galvanized steel. Shipping and installation costs for aluminum pipe are invariably lower than heavier pipe—usually from 15 to 30% less.

PIPE COSTS COMPARED

4" Schedule 40 Pipe (Plain End) 100 feet	*Carload Price	Freight to West Texas from Eastern U.S.	Total
Black Steel	98.37	15.86	114.23
Galvanized Steel	117.72	15.86	133.58
Aluminum Heavy End* Alloy 6063-T6	143.75	—(1)	143.75
Aluminum Alloy 6063-T6	179.15	—(1)	179.15
Stainless Steel 304 Schd. 10	621.77	15.86	637.63
Stainless Steel 304 Schd. 40	1065.80	15.86	1081.66

*Quoted as of March 25,1960 (1) Aluminum prices include delivery charges

The table also shows that aluminum pipe is the lowest-cost corrosion-resistant pipe you can buy. Reynolds Aluminum Heavy End Pipe costs about 1/4 as much as stainless 304, Schedule 10, and about 1/7 as much as stainless 304, Schedule 40.

RESISTS CORROSION, WON'T RUST OR CONTAMINATE

The list of corrosive chemicals and process products that aluminum can handle is a long one, and it includes fluids that rapidly corrode other metals. Corrosion-resisting aluminum is ideal for process operations in the chemical, food, beverage, soap, drug, petroleum and petrochemical industries.

LIGHTWEIGHT, BUT STRONG

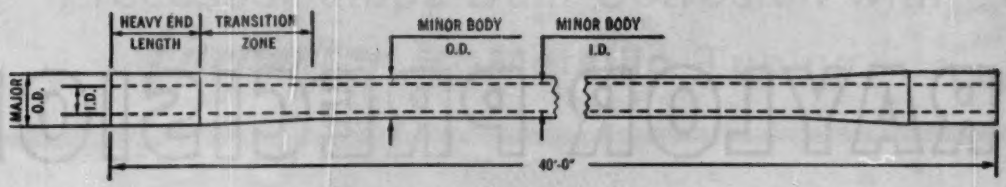
Only one-third as heavy as steel, Reynolds Aluminum Pipe costs less to handle, to ship, and to install. It requires less support, and is easier to move for temporary installations. Yet, aluminum is strong—strong enough to take rough handling and normal operating pressures. In fact, at lower temperatures (down to −320°F) where some metals grow brittle and weak, aluminum is actually *stronger*, with improved tensile and yield strengths, and ductility.

EASY TO WORK, WELD, JOIN

Aluminum is one of the easiest metals to form, bend, cut and join. It welds speedily and securely by any common welding method. You can choose from a large variety of forged and cast aluminum fittings, flanges and couplings for grooved, threaded, and welded joints. This means more design flexibility, lower installation costs. Other unique characteristics of aluminum pipe are also important: It is nonsparking, safer to use with volatiles. And, the smooth inside surface of Reynolds Aluminum Pipe means less danger of scale formation—you get improved product flow that can hold pumping costs down.

AVAILABILITY

Reynolds Aluminum Process Pipe is available in schedules 5, 10, 40 and 80. Diameters range from 1/8" to 12", and thicknesses range from .065" to .200". In addition, Reynolds Aluminum Pipe is available in both Duplex and Heavy-End types.



Reynolds Aluminum Heavy-End Pipe

HEAVY-END PIPE

Reynolds Aluminum Heavy-End Pipe can save up to 28% in piping costs. Heavy-End Pipe, with a constant inside diameter, is thicker at the ends to compensate for the loss in mechanical properties due to welding or grooving. Excess metal is eliminated in the pipe body and extra strength is provided where it's needed most—at the joint. It enables you to design a uniformly strong system without paying for extra metal, without overdesigning. Heavy-End Pipe is available in schedule 40 and 80 equivalents, and takes standard fittings.

REYNOLDS DUPLEX PIPE

Reynolds Duplex Pipe is actually a two-pipe steam trace system in one. A dividing wall inside the tube provides two separate channels—one for steam or condensate, the other for the viscuous product. Duplex eliminates an outside steam line and the cost of fastening the two pipes together, and it minimizes insulation needs.

REYNOLDS–FOR ALUMINUM PIPE, ALUMINUM KNOW-HOW

When designing any process system, plan for economy and long, efficient service; plan with Reynolds Aluminum Process Pipe. For details, contact your local Reynolds office, or write for complete file on the uses of aluminum in the chemical process industry. Use coupon below.

Reynolds Aluminum Duplex Pipe

REYNOLDS ALUMINUM SPECIALTY PIPE DISTRIBUTORS

A. B. Murray Company, Elizabeth, New Jersey

Boston Pipe & Fittings Company, Inc.
Cambridge, Massachusetts

Gulf Coast Marine Supply Company
Mobile, Alabama; Pensacola, Florida

Gulf Supply Company, Beaumont, Texas

Industrial Piping Supply Co., Charlotte, N.C.

McJunkin Corporation, Charleston 22, West Virginia

Piping Products Company, Inc.
Moorestown, New Jersey

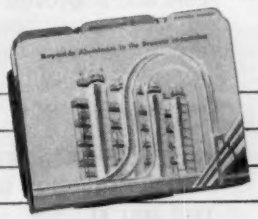
Horace T. Potts Company, Philadelphia 34, Pennsylvania

C. A. Roberts Co., Franklin Park, Illinois;
Indianapolis, Ind.; Tulsa, Okla.; Detroit, Mich.;
St. Louis, Mo.; Kansas City, Mo.

Watch Reynolds new TV show "Harrigan & Son", Fridays; also "All Star Golf", Saturdays—ABC-TV.

REYNOLDS ALUMINUM

WRITE FOR REYNOLDS DATA FILE
Aluminum for Chemical Process Uses



Reynolds Metals Company
P.O. Box 2346-CM • Richmond 18, Virginia

Please send me your free data file on Aluminum for Chemical Process Applications.

*Name*_____

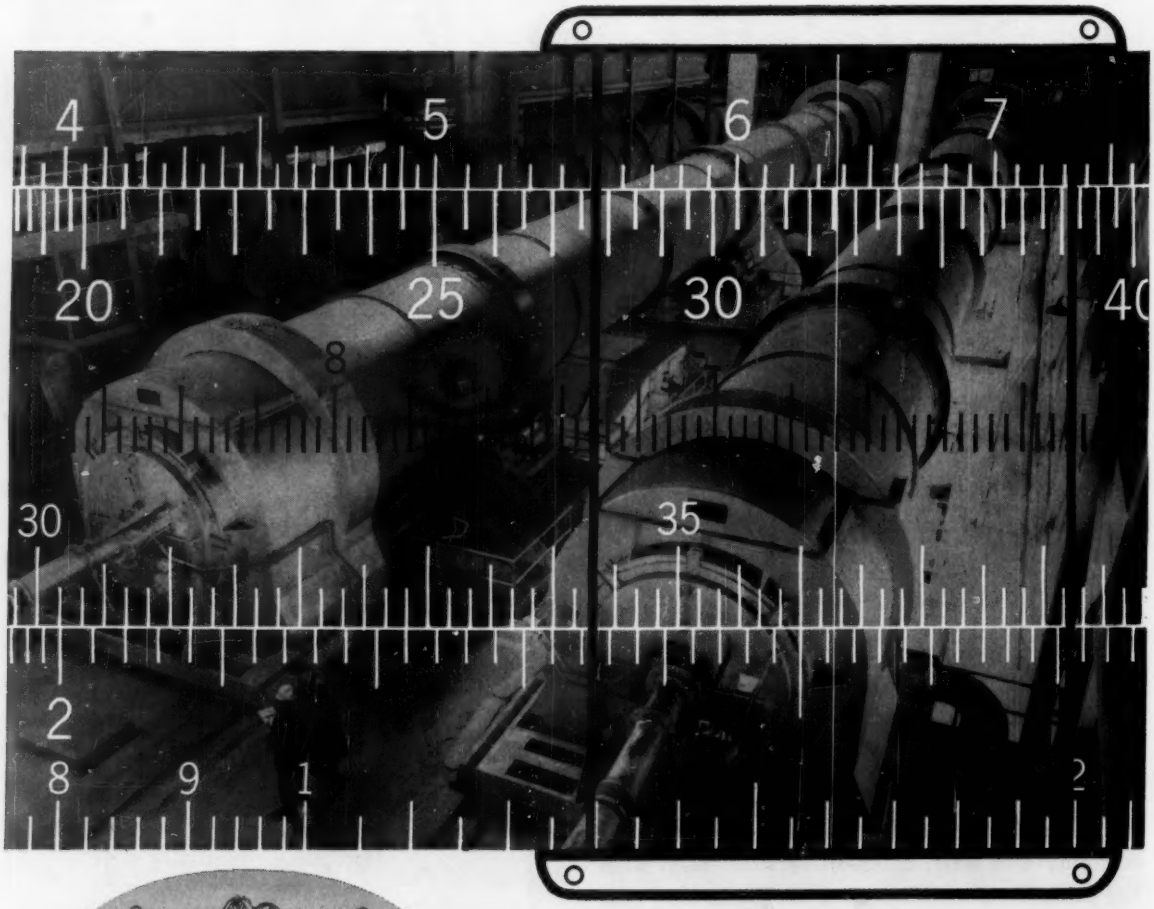
*Company*_____

*Address*_____

*City*_____ *Zone*____ *State*_____

TRAYLOR PRECISION

from design through installation to operation



Shown above are two* 11′-3″ x 300′ dry process Traylor kilns designed to meet the specific needs of the Lone Star Cement Plant in Nazareth, Pennsylvania. These modern rotary kilns feature full-floating type roller ring and roller supports which insure easy alignment, continuous operation and low maintenance costs. Traylor rotary kilns have all welded steel shells, feed and discharge end seals and improved kiln feed.

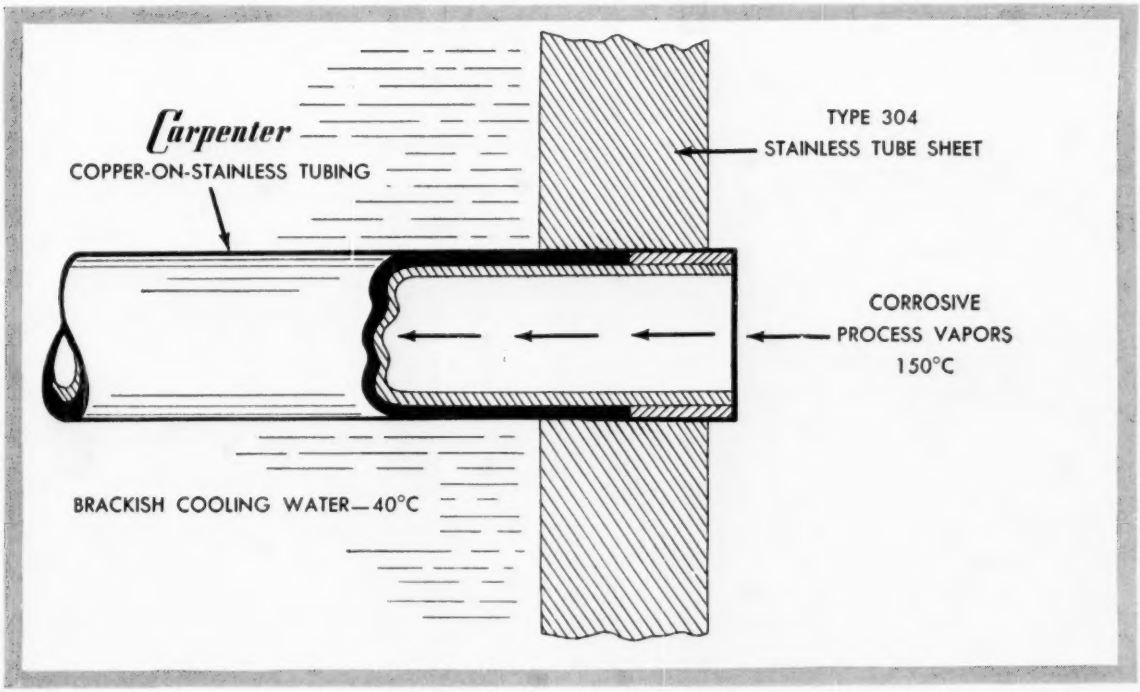
Write today outlining your kiln requirements and let our engineers make recommendations . . . or write for Bulletin No. 1115.

*Shown in the background are two additional Traylor Kilns, 11′-3″ x 270′.

TRAYLOR ENGINEERING & MANUFACTURING
DIVISION OF FULLER COMPANY
1551 MILL ST., ALLENTOWN, PA.

TKA-7

Processor stops Dual Corrosion with *Carpenter* Bi-Metallic Tubing

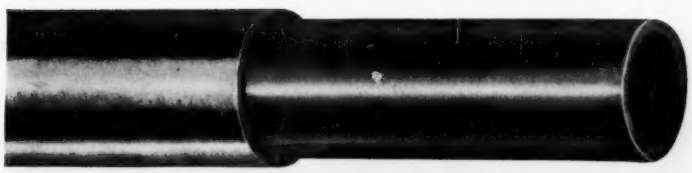


- Two dissimilar corrodents in heat exchange processing equipment raised havoc with stainless tubing. Hot corrosive vapors caused little trouble within the tubes. But brackish cooling water on the shell side was a real problem. The stainless tubing had to be replaced every two years at a cost of about $20,000 in materials, labor, and downtime.

  After unsuccessful trials with several special stainless grades, Carpenter Bi-Metallic Tubing was installed in the problem condenser. It was 18 gauge Type 304 welded stainless on the inside bonded mechanically to .035" deoxidized copper tubes on the outside. Ferrules on the tube ends facilitated rolling into Type 304 stainless tube sheets.

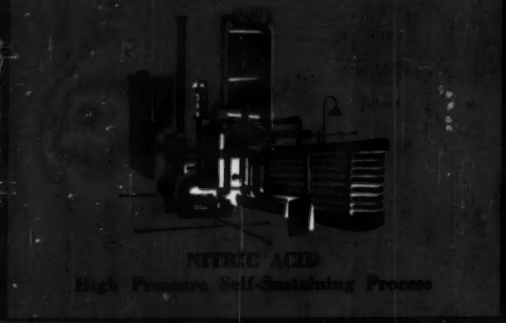
  After more than four years, Carpenter's Bi-Metallic Tubing was still operating —with life expectancy set for 8-10 years of trouble-free service.

  Carpenter Bi-Metallic Tubing is available in a variety of stainless-carbon, copper, brass and other combinations to solve dual corrosion problems. For details or help, call your nearby Carpenter representative or contact The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

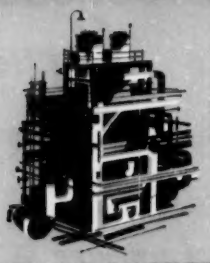


your master key to cost savings

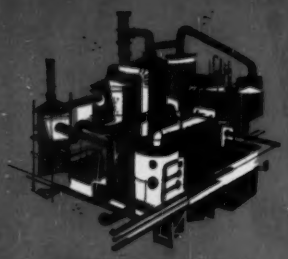
Bi-Metallic Tubing



NITRIC ACID
High Pressure Self-Sustaining Process

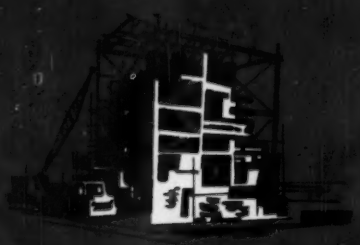


SULFURIC ACID CONCENTRATOR



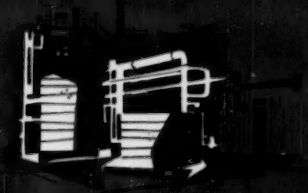
SULFURIC ACID

the C&I



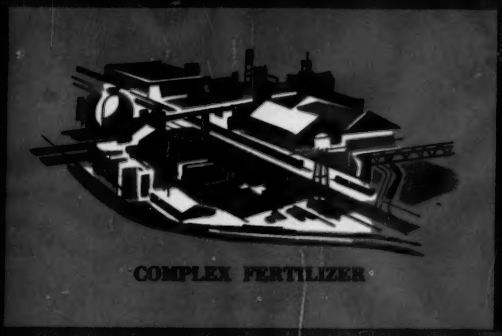
NITRIC ACID—Concentrating Plant

AMMONIUM NITRATE—Prill Tower



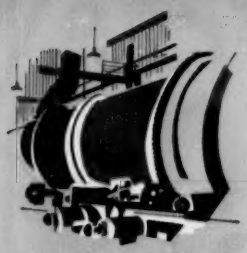
NITROGEN SOLUTIONS
Vacuum Evaporation Process

Here is C&I's 1961 showcase of plants and processes for the production of superior fertilizer products. For more information on any of these proven processes, write today for the new C&I brochure which contains comprehensive descriptive data and flow sheets.



COMPLEX FERTILIZER

showcase for '61



SPHERODIZER PROCESS

PHOSPHORIC ACID

C&I THE CHEMICAL AND INDUSTRIAL CORP.

CINCINNATI 26, OHIO, U.S.A.

KENNEDY

PNEUMATIC CONVEYING SYSTEM

For over twenty-five years, KENNEDY has designed and built pneumatic conveying systems for America's largest industrial concerns. Let us show you how a KENNEDY System can be the most economical for *your plant.*

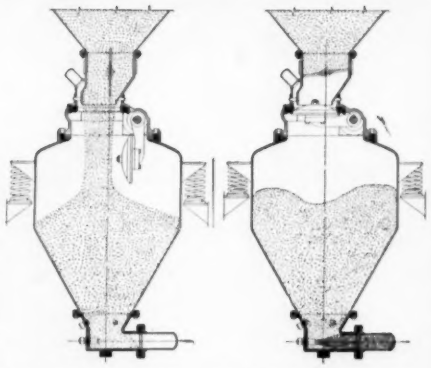
- **has NO MOTORS, screws or high speed moving parts**
- **uses higher pressures for greater efficiency and smaller pipelines**
- **uses air only when moving material at full capacity**
- **automatically measures quantities conveyed**
- **can handle several materials through one pump and pipeline without contamination**

TYPICAL MATERIALS HANDLED

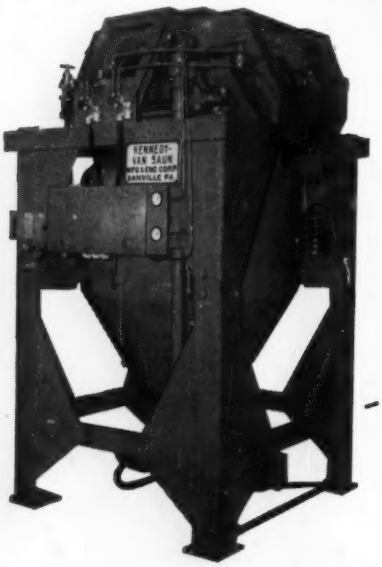
Carbon black	Lump lime
Hydrated lime	Cement
Petroleum coke	Barium sulphate
Aspirin crystal	Sodium bicarbonate
Soda ash	Anthracite coal
Dolomite	. . . and many others

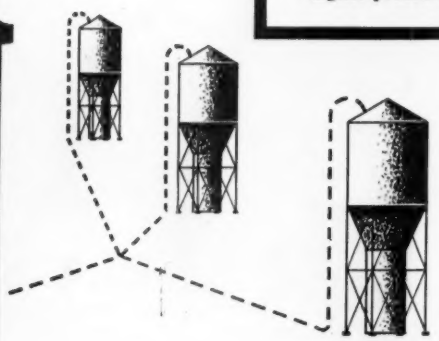
The KENNEDY Pneumatic Conveying System requires less maintenance because:

- only these small, inexpensive parts are subject to wear;
- these parts are readily accessible—replacement is a matter of minutes;
- you get months of high capacity operation without attention.



The exclusive batch cycle of the KENNEDY Pneumatic Conveying Pump eliminates contact of material with moving parts. Completely sealed tank during discharge permits use of higher pressures for greatest efficiency.





Send for literature describing KENNEDY *Pneumatic Conveying Pumps, Air Activated Containers, Air-Float Air-Gravity Conveyors, Complete Pneumatic Conveying Installations, and Research and Testing Services.*

KENNEDY VAN SAUN

MANUFACTURING & ENGINEERING CORPORATION

405 PARK AVENUE, NEW YORK 22, N.Y. • FACTORY: DANVILLE, PA.

IN THE PHOSPHATE FIELDS OF FLORIDA, Virginia-Carolina Chemical Corp. is expanding production facilities of its 40-acre phosphate plant. Engineer and contractor Wellman-Lord Engineering, Inc., of Lakeland, Florida, employed the Westinghouse coordinated project plan for electrical equipment. This single-source facility eliminates many of the headaches usually encountered in equipment installations involving multiple suppliers.

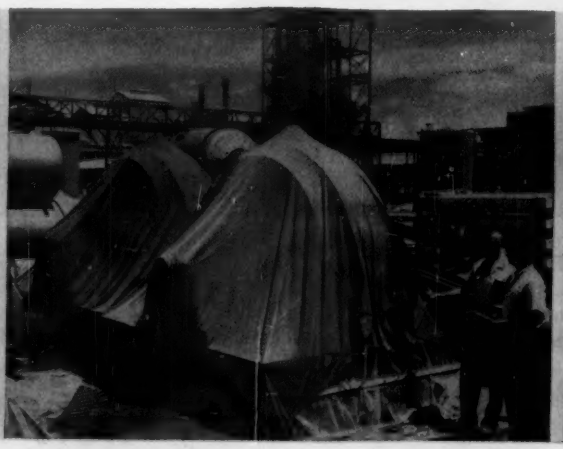
J-96158

HOW TO GROW BIG WITH FEWER GROWING PAINS...

RESISTS CORROSION . . . The new Westinghouse Life-Line® "A" totally enclosed motors installed at this plant have been specifically designed to resist highly corrosive atmospheres created here by sulfuric acid (wet process) and phosphoric acid. Basic protection is provided by heavy cast-iron frames, brackets and conduit boxes. Other Life-Line "A" features include nonsparking, noncorrosive fans protected by heavy cast-iron hoods, flingers which protect against moisture entry, and high integrity Westinghouse insulation system. The four 50-hp TEFC motors (above) are on the fluorine recovery unit.

J-96158-2

SAFER . . . Westinghouse metal-clad high-voltage switchgear provides unusual safety through interlocking devices and full steel barriers in a completely compartmentalized design.



LASTS LONGER . . . These two Westinghouse 800-hp synchronous motors arrived at the job site *before* the promised delivery date. They will drive the ball mills for phosphate rock grinding. Exclusive Westinghouse Thermalastic® insulation tests out at 20 times longer life than other insulations. Insulation life expectancy is estimated to be 100 years.

LESS UPKEEP . . . Westinghouse Ampgard* high-voltage starters simplify and reduce maintenance. Contactors are completely serviceable without being removed from the starter. Tilt-out arc chutes of contactor permit immediate inspection and quick replacement.

*Trade-Mark

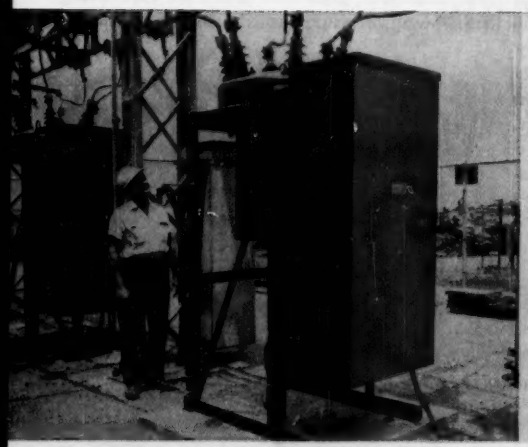
WESTINGHOUSE SINGLE-SOURCE RESPONSIBILITY MEANS LESS PAPERWORK, UNDIVIDED RESPONSIBILITY, FULLY COMPATIBLE EQUIPMENT

Two hundred and two motors of various ratings—five assorted transformers—two 14.4-kv oil circuit breakers—two indoor switchgear units—enough starters to fill four control center rooms. This is the apparatus involved in the electrical system for Virginia-Carolina Chemical Corporation's new phosphate plant in Nichols, Florida.

Putting such a complex system as this on the line could pose formidable problems in coordinating purchasing and deliveries. But both Virginia-Carolina Chemical Corp. and Wellman-Lord Engineering, Inc., of Lakeland, Florida, decided from the beginning to utilize Westinghouse single-source responsibility. Here were the benefits: *A single standardized line of coordinated electrical equipment . . . a single point of contact . . . a single order number . . . a single individual responsible for price negotiation, delivery, schedules and start-up.* Results: A big reduction in paperwork. Substantial savings in engineering time. Prompt deliveries.

Let us know about your expansion plans. Westinghouse can develop a program to meet your short-range and long-range plans . . . aimed at economy. Why not talk to your Westinghouse representative early in the planning stages? *You can be sure . . . if it's Westinghouse.*

Westinghouse



FULLY PROTECTED . . . George Bunch, Westinghouse Service Engineer, inspects 14.4-kv oil circuit breaker. Automatic reclosing equipment restores service to protect incoming lines or feeder circuits from prolonged and costly outages.

MORE ECONOMICAL . . . One of the two Westinghouse 750-kva transformers at Virginia-Carolina's new Nichols plant. Ratings of the plant's three other Westinghouse transformers are 500 kva, 1000 kva and 2000 kva. These Inerteen®-filled transformers for chemical use offer the many economies of Westinghouse standardization and engineering design advantages based on years of proved experience.

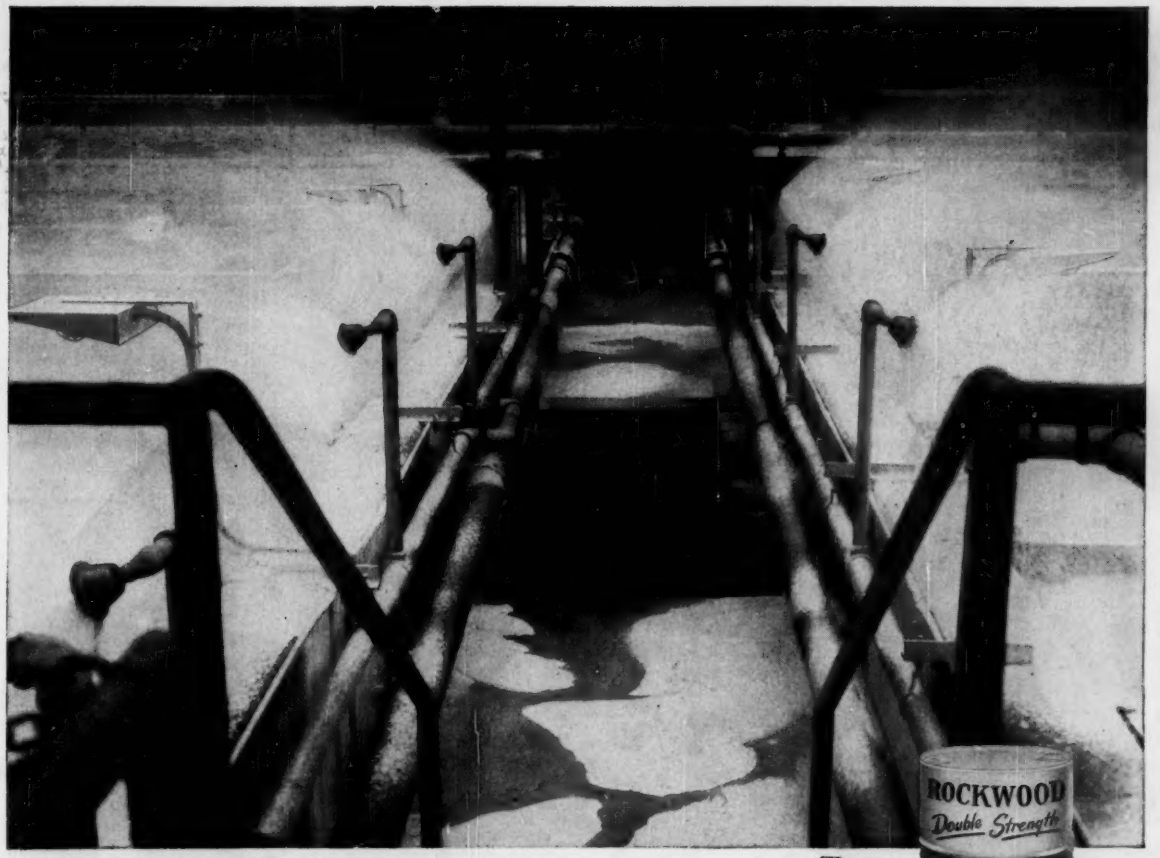
J-96158-3

HIGH-VOLTAGE TEAM . . . Seated at left, W. F. Karns, Wellman-Lord Engineer, goes over plans for expanding Virginia-Carolina Chemical's Charles T. Harding Plant in Florida. Single-source responsibility for negotiation, delivery and start-up of electrical equipment is represented by Westinghouse Sales Engineer W. B. McGuire, seated right. Contributing their specialized knowledge and experience to the $12 million project are, standing left to right, Chief Electrical Engineer J. H. Ham, Chief Field Engineer D. R. Mossberger (both of Wellman-Lord Engineering, Inc.) and Plant Manager W. C. Thomas of Virginia-Carolina Chemical Corp. J-96158-4

Westinghouse

IF YOU'RE PLANNING TO EXPAND, REMEMBER...

WESTINGHOUSE SINGLE-SOURCE RESPONSIBILITY MEANS LESS PAPERWORK, UNDIVIDED RESPONSIBILITY, FULLY COMPATIBLE EQUIPMENT



Testing a Rockwood FogFOAM System that guards the oil separator pits in Cincinnati Gas & Electric Co.'s plant.

Here's high protection *against* low flash-point fires!

In any group of oil separator pits, the pit with the lowest flash point sets the danger mark for the entire area.

To installations of this type — and to many others endangered by fire — Rockwood FOAM and FogFOAM systems bring the surest, most dependable fire protection ever developed.

In the FogFOAM system shown above, protection starts with the heat detectors located around the pits. During any critical temperature rise these detectors sense the inception of fire. The signal is transmitted automatically — and the FogFOAM system goes into instant action.

Rockwood FOAM liquid, mixed with water and air, is then released through many FogFOAM heads over each pit. Within a few seconds a thick blanket of Rockwood FOAM completely covers the threatened area . . . *A disastrous fire has been prevented.*

Fire protection systems are custom engineered by Rockwood to meet the needs of every type of oil and gas installation. Send the coupon for details.

Double Strength FOAM Liquid Gives Double Protection. Three parts of Rockwood Double Strength FOAM liquid mixed with 97 parts of water and 900 parts of air form a fire-smothering blanket that quickly reseals itself. You pay for only three parts per thousand for this extinguishing agent that has proved its ability to put out spill fires in flammable liquids, with maximum speed and safety for personnel. Tested and listed by Underwriters' Laboratories, Inc. Branch Offices in all principal cities.

ROCKWOOD SPRINKLER COMPANY

A Division of The Gamewell Company • Subsidiary of E. W. Bliss Company

Engineers Water... to Cut Fire Losses

Distributors in all principal cities

ROCKWOOD SPRINKLER COMPANY
A Division of The Gamewell Company
526 Harlow Street
Worcester 5, Mass.

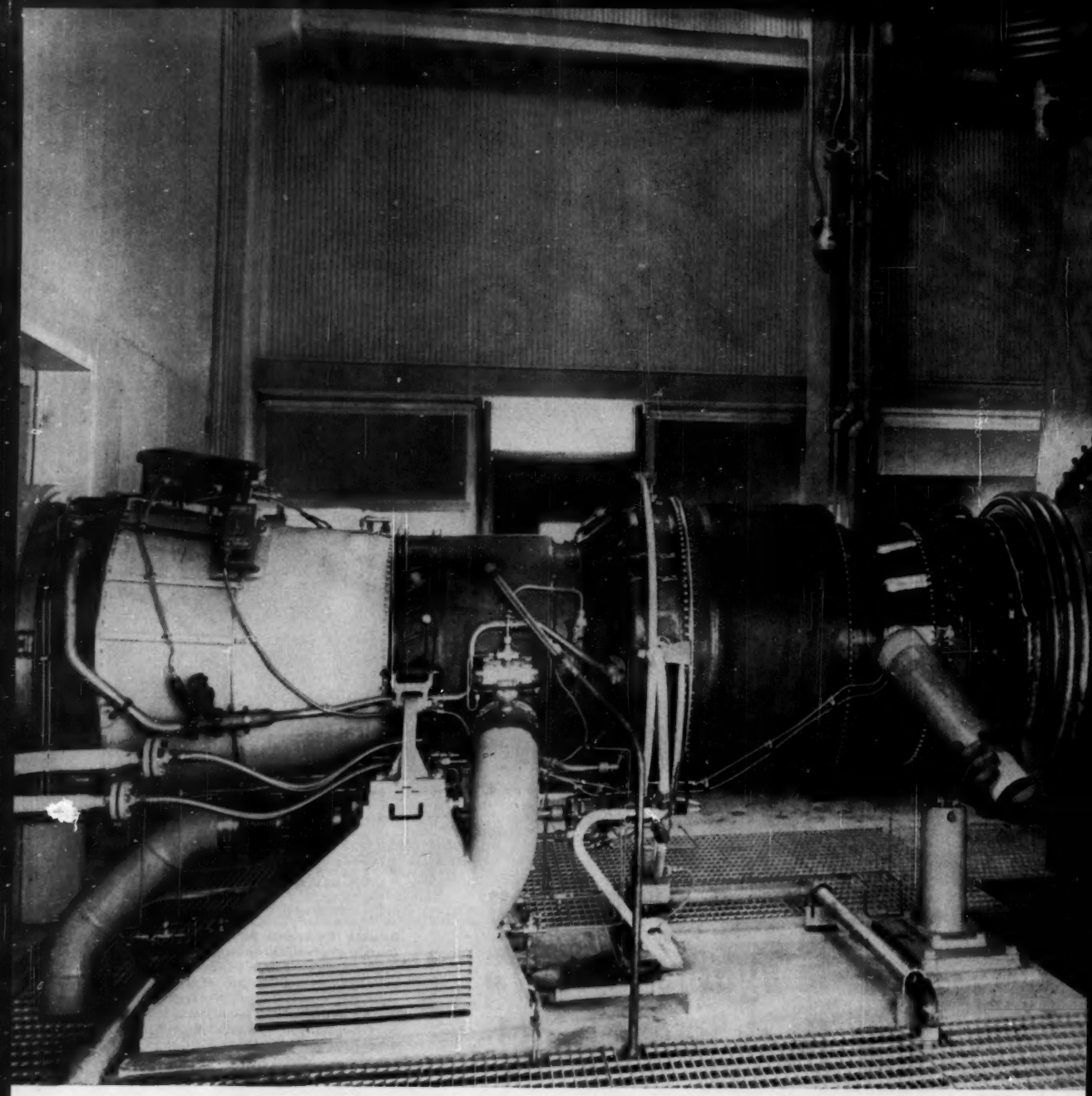
Please send me information on Rockwood fire-fighting products and systems.

Name.....

Title.....

Company.....

City.....*Zone*..*State*.....



R. L. Boyer, *Vice President and Director of Engineering, and* W. B. Boyum, *Manager of Gas Turbine Sales, The Cooper-Bessemer Corporation report . . .*

World's first jet powered gas turbine is now on the job

YOU are looking at a revolutionary new concept in industrial power. This Cooper-Bessemer 10,500 hp RT-248 gas turbine with a modified J-57 aircraft jet engine introduces new, drastic economies in plant construction, operation and maintenance. Shown here on the job at the Clementsville (Kentucky) Compressor Station of Columbia Gulf Transmission Company, this powerful, compact unit has taken on the total gas-boosting load of the station, operating 'round the clock. Find out how this outstanding joint development of Cooper-Bessemer and Pratt & Whitney Aircraft can fit into *your* plans for compressors, generators and other rotating machinery. Call our nearest office.

BRANCH OFFICES: Grove City • New York • Washington Gloucester • Pittsburgh • Detroit • Chicago • Minneapolis • St. Louis Kansas City • Tulsa • New Orleans • Shreveport • Houston Greggton • Dallas • Odessa • Pampa • Casper • Seattle San Francisco • Los Angeles • SUBSIDIARIES: Cooper-Bessemer of Canada, Ltd.... Edmonton • Calgary • Toronto • Halifax Stratford • C-B Southern, Inc.... Houston • Cooper-Bessemer International Corporation ... New York • Caracas • Anaco • Cooper-Bessemer, S.A.... Chur, Switzerland • The Hague, Netherlands Mexico City • The Rotor Tool Company, Cleveland

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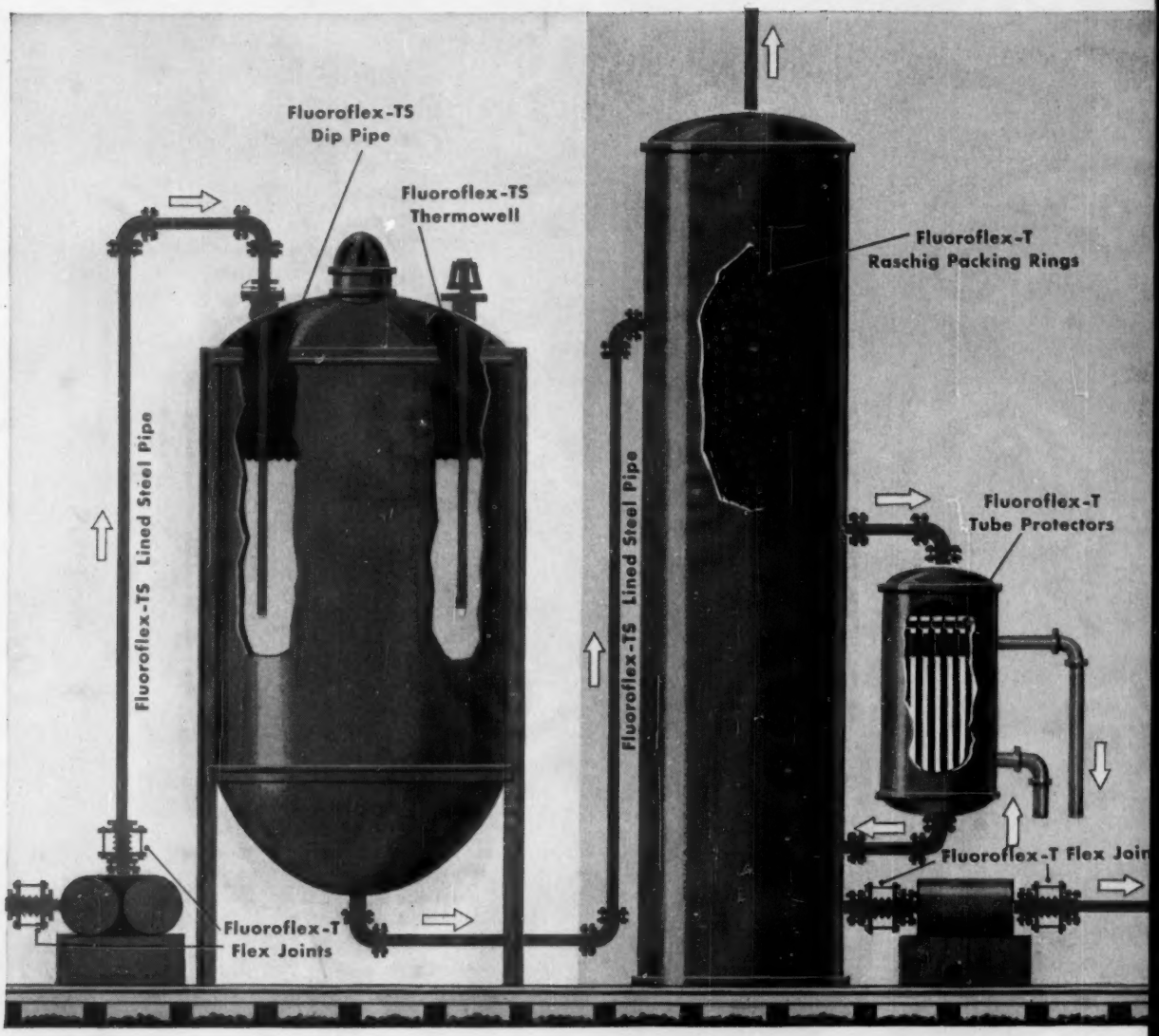
ENGINES: GAS - DIESEL - GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL, ENGINE, TURBINE OR MOTOR DRIVEN



HERE'S WHY corrosion-proof fluid-handling production savings,

Check these Fluoroflex-T piping components for economy, installation ease, long life!

FLUOROFLEX-TS—Lined Steel Pipe. Prefabricated to length with flanges—ready to assemble. Minimizes assembly time, shortens checkout time.

FLUOROFLEX-T—Bellows-Flex Joints. Molded rather than machined, for unparalleled flex life. Damp out equipment vibration, adjust to longitudinal and temperature movements, add years to life of equipment and piping.

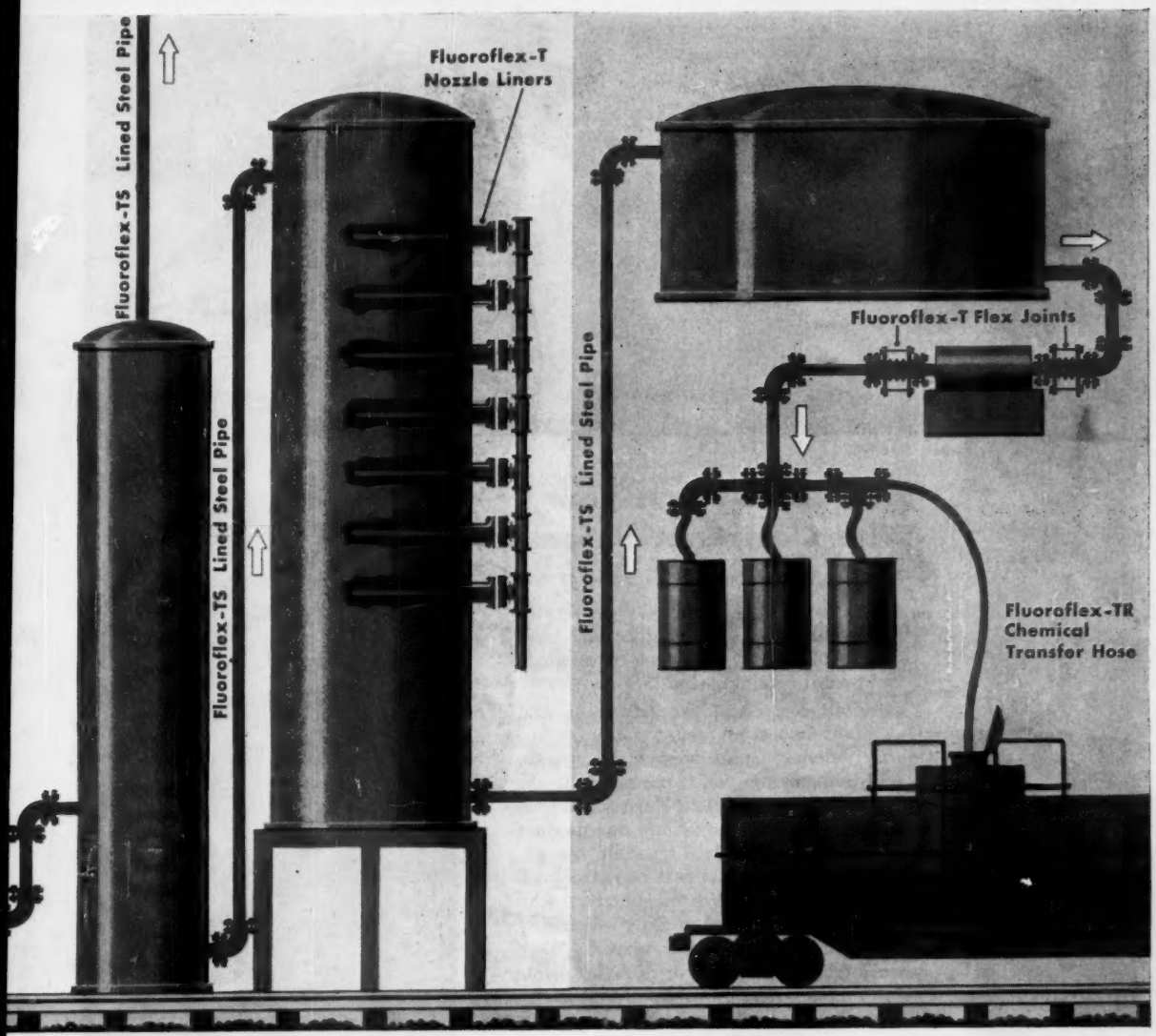
FLUOROFLEX-T—Transfer Hose. Completely corrosion-resistant, long flex life. Cover of rubber or stainless steel braid.

FLUOROFLEX-T—Condenser Tube Protectors. Eliminate erosion and corrosion by high-velocity acid on entry side of condenser tubes.

Also: Raschig Packing Rings • Dip Pipes • Spargers • Thermowells.

Fluoroflex®-T Piping Products as shown above can be used with complete and proven assurance that they will not corrode or build up solids which can contaminate sensitive products. Specially processed of Teflon® resins by patented Resistoflex methods, they can handle the most difficult materials up to 500°F. They are completely resistant to any chemical except high-temperature fluorine and the molten alkali metals.

Fluoroflex-T Piping costs no more on an installed-cost basis than other corrosion-proof systems in common use today. Initial material costs have been



components of FLUOROFLEX-T (TEFLON) assure non-contamination:

lowered by recent price reductions made possible by advanced technology and increasing volume. Installation costs are inherently low as a result of skillful design which features easily-bolted-together units with prefabricated, flanged sections.

Fluoroflex-T Piping costs LESS on a performance basis. Savings in operation are assured—with decreased maintenance, long service life, and the elimination of process headaches and downtime.

So, if *you* have problems of corrosion—want to reduce maintenance or replacement costs and eliminate process downtime or product loss—consult Resistoflex. Write for more information today.

RESISTOFLEX
CORPORATION

Complete systems for corrosive service

Plants **in Roseland, N. J. • Anaheim, Calif. • Dallas, Tex.**

Sales Offices **in major cities**

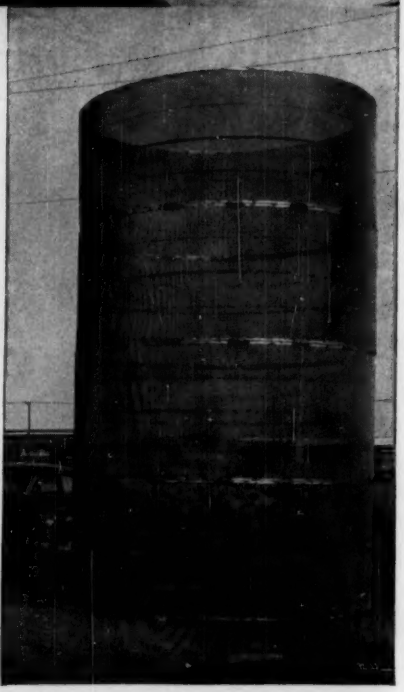
®Fluoroflex is a Resistoflex trademark, reg. U. S. Pat. Off.
®Teflon is Du Pont's trademark for TFE fluorocarbon resins.

Who cares about your Wire Cloth Fabrications?

CAMBRIDGE does . . .

that's why you automatically get service with your order . . . whether you need dozens of midget strainers or a single giant-sized retaining screen.

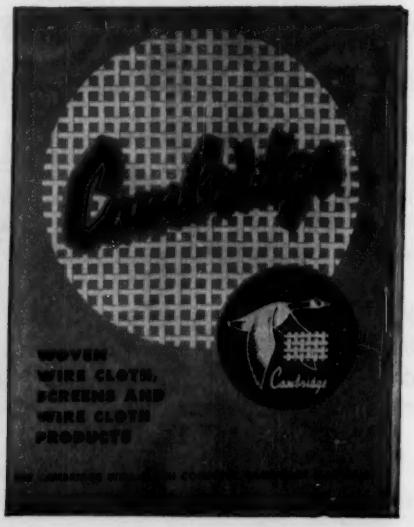
Careful, competent workmanship and constant inspection assure you of quality . . . modern machinery and accurate scheduling assure you of prompt delivery. And, a Cambridge Field Engineer follows up your order to make sure our product is giving you the best possible service. Let us quote on your next order for wire cloth fabrications. We manufacture wire cloth from any metal or alloy—including titanium—in nine basic weaves. We'll work from your prints or draw up prints for your approval. Call your Cambridge Field Engineer . . . he's listed in the yellow pages under "Wire Cloth". Or, write for FREE 94-PAGE CATALOG.



The Cambridge Wire Cloth Co.

Department G • Cambridge 12, Md.

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications



Progress Report...

New nonionic

TERGITOL Nonionic TP-9 is a new addition to CARBIDE's long line of nonyl phenol-ethylene oxide condensates. It is similar to CARBIDE's widely used TERGITOL NPX—except for a lower cloud point. TERGITOL TP-9 has a cloud point of 51-56°C. (124-131°F.), compared with 61-66°C. (142-151°F.) for TERGITOL NPX.

TERGITOL TP-9 is designed for both liquid detergents and dry "controlled-sudsing" detergents. It is a crystal-clear liquid and has excellent grease-dispersing and low foaming characteristics.

The specification limits of TERGITOL Nonionic TP-9 are controlled for optimum results in household detergents.

SPECIFICATION LIMITS

pH of a 10% solution in water	5.0 to 8.0 at 25° C.
Water	0.3% by wt., max.
Ash	0.05% by wt., max.
Cloud point of a 0.5% solution in water	51 to 56° C.
Color	100 Pt-Co, max.
Odor	Mild and pleasant

For physical properties and price information on TERGITOL TP-9, use the coupon at right.

More uses for ethylene glycol

Although ethylene glycol is best known for its anti-freeze applications, it is widely used for many other purposes. For example, when esterified with polybasic acids, ethylene glycol forms resins for laminating and surface coatings. It can also be used in the manufacture of polyester fiber and films. With pentaerythritol, ethylene glycol produces alkyd resins for paints and enamels.

Ethylene glycol should be evaluated as a solvent and conducting medium for ammonium perborate, the conductor in most dry-type capacitors. It is also a valuable solvent for stains, soluble oils, resins, special varnishes and enamels, and some dyes and inks.

A 62-page booklet lists and describes CARBIDE's glycols, their properties, and scores of applications. For a copy of "Glycols," use the coupon at right.

Isobutyl alcohol and acetate reduce lacquer costs

Economy and broad utility are two important reasons for the expanding use of isobutanol and isobutyl acetate in the lacquer industry.

The following table lists some of the principal properties of CARBIDE's isobutyl solvents:

	Isobutanol	Isobutyl Acetate
Relative evaporation rate (Butyl Acetate = 100)	74	145
Dilution Ratio		
Toluene	2.4*	2.7
Naphtha	—	1.1
Relative viscosities of lacquers at 25°C. (Butyl Acetate = 100)		
N Formula	—	95
ND Formula	—	95
NRAD Formula	230*	85
NRMD Formula	—	95
Flash point (open cup tester), °F.	100	88
Weight per gallon at 20°C., lb.	6.7	7.2

*Mixture of 30% isobutanol and 70% butyl acetate (98% ester)

The low specific gravities of these products give substantial savings when per-pound purchases are converted into per-gallon sales.

CARBIDE's high-purity isobutanol not only serves as a latent solvent and as a viscosity reducer, but also as an intermediate in production of ester solvents and plasticizers.

Isobutyl acetate has properties paralleling n-butyl acetate and other acetate mixtures.

In addition to the attractive cost differential that goes with isobutyl alcohol or acetate, other economies are obtainable through bulk shipments with other CARBIDE solvents.

Tear out this coupon. Check the boxes on which you'd like more information, and mail to Dept. H, Union Carbide Chemicals Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N.Y.

☐ Isobutyl Alcohol ☐ TERGITOL TP-9

☐ Glycols

Name_____

Position_____

Company_____

Street_____

City_____ Zone_____

State_____

And remember, you can obtain the services of a CARBIDE Technical Representative who's backed by Technical Specialists.

TERGITOL and UNION CARBIDE are registered trade marks.

UNION CARBIDE CHEMICALS COMPANY

UNION CARBIDE

How to Cut Controllable Costs with Armco Stainless Steels

In the face of inflation, higher labor costs and taxes, profits must be protected by lowering costs that can be controlled. In many chemical plants this is being done by effective use of Armco's standard and special steels. They have made possible reductions in maintenance expense, overall cost of equipment, production time, and losses from product contamination.

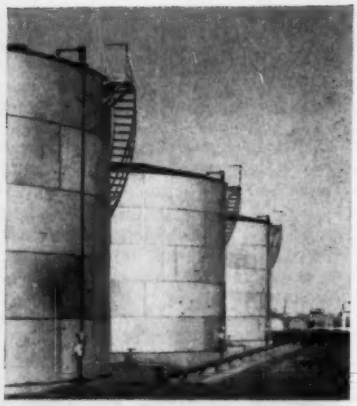
Meet Chemical Processing Needs

In addition to standard stainless grades, Armco produces variations of these, as well as many special stainless steels that are designed to help solve chemical processing problems. They include the extra-low carbon types, 304L, 316L and 317L; the ultra-high strength precipitation-hardening stainless steels, Armco 17-4 PH, 17-7 PH, and PH 15-7 Mo; and grades like Armco 17-14 CuMo, 22-4-9, and 17-10 P that offer useful combinations of strength at high temperatures and improved resistance to oxidation and corrosion.

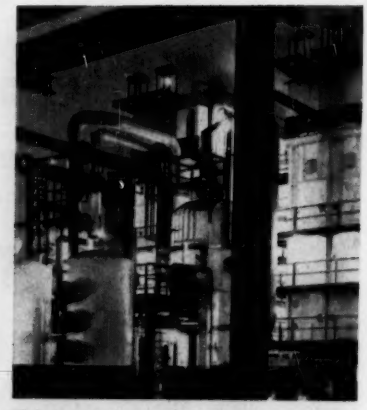
Get These Manuals

To assist you in selecting the most economical grades Armco has a complete library of technical bulletins and manuals available. Typical examples are two new booklets, *How Armco Stainless Steels Serve the Petrochemical Industry* and *How Armco Stainless Steels Improve Pulp, Paper and Profit.*

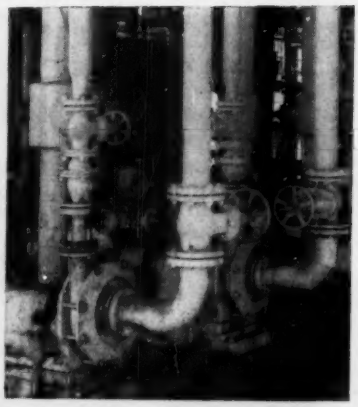
Use the advantages of Armco Stainless Steels in *your* cost reduction program. Write us today or contact your Armco Stainless Steel distributor. Armco Steel Corporation, 3200 Curtis Street, Middletown, Ohio.



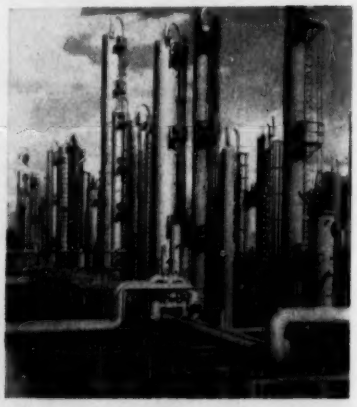
Storage tanks



High temperature equipment



Pumps and valves



Distillation and absorption towers

New steels are born at Armco

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

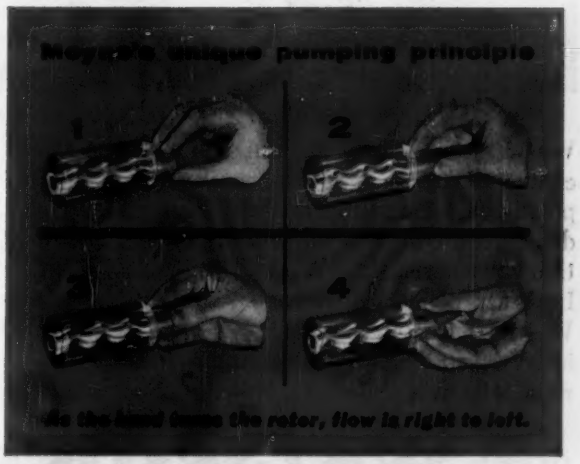
MOYNO®
CHEMICAL PUMPS

MOYNO® Progressing Cavity Pumps Handle Chemicals that *Ruin Other Pumps!*

MOYNO's unique *"progressing cavity"* principle and special resistant internal parts slash pump maintenance costs on problem chemicals that ruin other pumps. Any chemical that can be forced through a pipe—from thin watery slurry to extremely viscous rubber dough—can be pumped with a MOYNO.

As illustrated at right and in the cutaway model above, a rugged screw-like rotor turning inside a double-threaded stator forms *"progressing cavities"* which move chemicals smoothly. Fluids are pumped without turbulence, agitation or pulsation, and discharged uniformly. Rotor and stator materials resist abrasion and corrosion. Hundreds of difficult chemicals successfully handled prove that MOYNOS show little wear, even after long service. They have increased production and greatly lowered downtime on many jobs where they replaced other type pumps which had run up prohibitive maintenance costs or failed completely. On other jobs, MOYNOS have succeeded where chemicals were formerly moved by hand or other expensive means because they were considered unpumpable.

MOYNOS are available in capacities up to 500 gpm; pressures up to 1000 psi. Off-the-shelf replacement parts are always immediately available. To find out how you can decrease chemical pumping costs, write today for Bulletin 40 CE



ROBBINS & MYERS, INC.
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps
SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

the **WALWORTH CUSTOMER** *wants* **PLASTIC VALVES**
and **FITTINGS** *that can't corrode*
...here's how he gets them

When the Walworth Customer is faced with the control of corrosive fluids, he looks at dozens of plastic valves and checks them for himself. He demands answers to questions like these: Can this valve corrode? Is it toxic? Is it non-aging? In Walworth PVC Valves and Fittings, the Walworth Customer finds his answers. Not only is PVC nontoxic and non-aging, – it *can't* corrode. *All* parts are made of plastic. Valves and fittings have high burst strength. Given those facts the Walworth Customer buys.

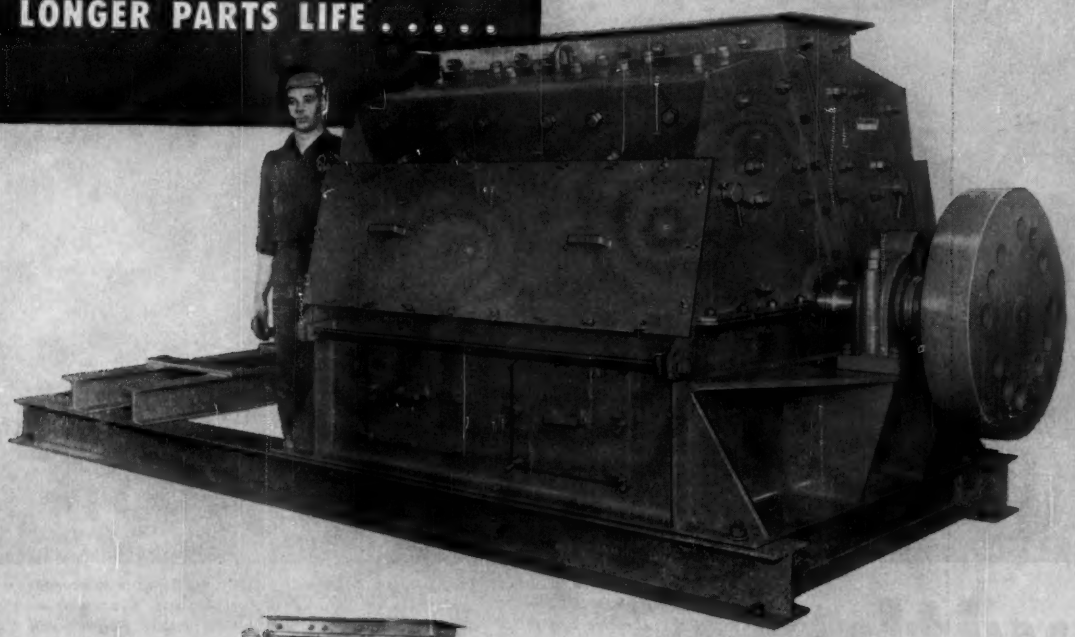
That may be the way you like to buy valves, too. If you insist on knowing about materials, workmanship and high quality, we'd like you for a Walworth Customer, too. For the newest literature on the complete line of PVC Valves and Fittings, get in touch with your Walworth Distributor.

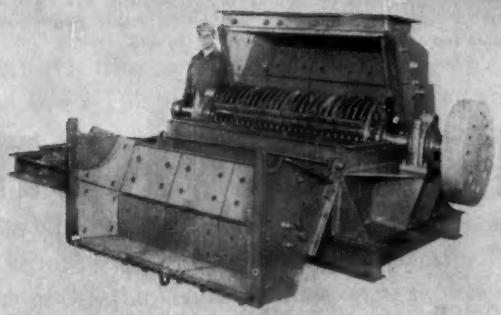
Or write **WALWORTH** *750 Third Avenue, New York 17, N. Y.*
DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

WALWORTH SUBSIDIARIES: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO. M&H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING & WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.

NEW DUAL "2-POINT" ADJUSTMENT INSURES MORE UNIFORM GRINDING, LONGER PARTS LIFE . . . . .

WILLIAMS *Reversible* HAMMER MILLS





Williams Reversible Hammer Mill with cover open.
Note these features:

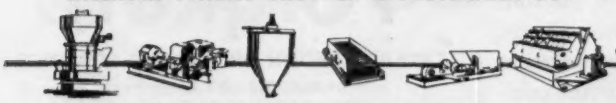
- Super-strong reinforced steel plate frame
- Renewable wear-resistant manganese steel liners
- Heavy duty oversize forged steel rotor shaft
- Anti-friction self-aligning roller bearings in dust-tight housings
- Complete accessibility to interior for quick parts changing

It's another Williams "first"—features not available in other hammer mills—that now makes it possible to maintain the original close clearances of *both* grinding plates *AND* cage sections against the rotating hammers. This easy-to-make "2-point" adjustment, in the most critical grinding area inside the hammer mill, gives absolute assurance of consistently uniform product quality.

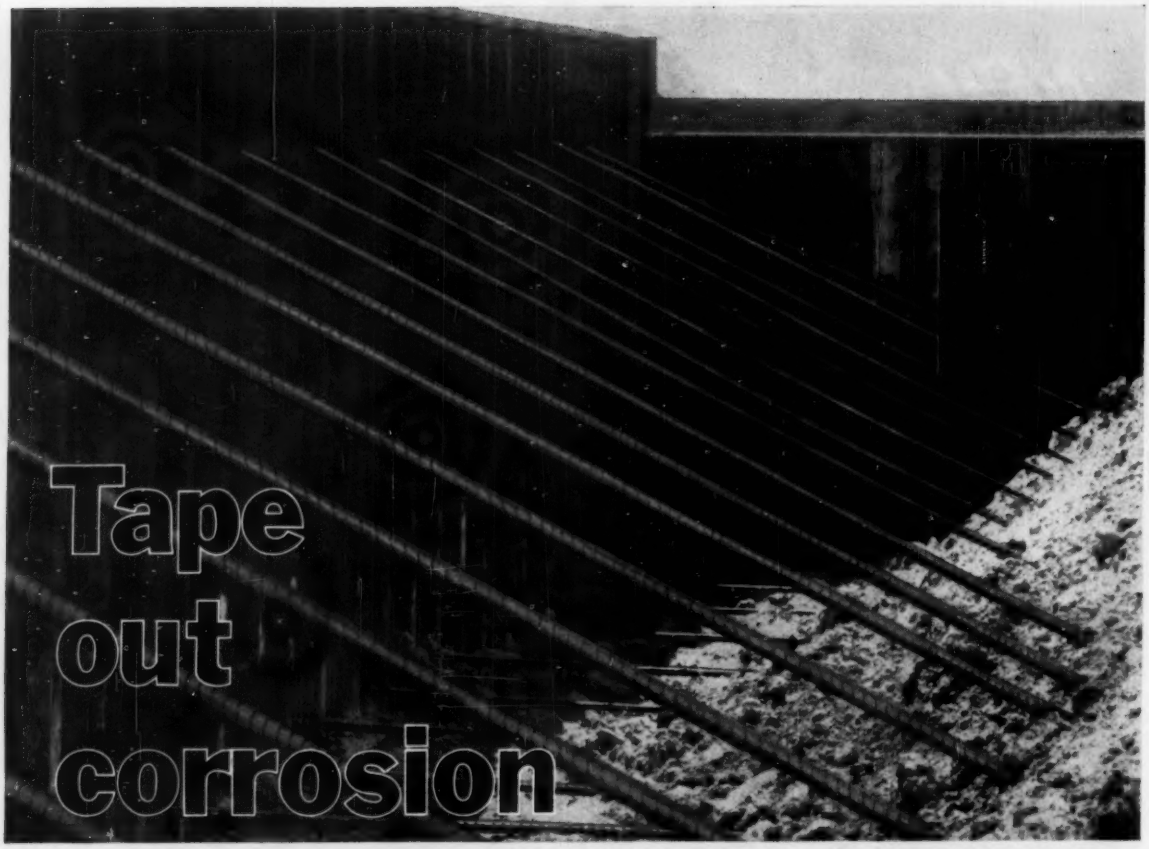
In addition to the advantages of the Dual "2-Point" Adjustment, a Williams Reversible Hammer Mill substantially lowers upkeep expense by cutting hammer cost. Hammers can be operated in one direction today and another tomorrow simply by installing a simple reversing switch on the driving motor. Manual reversing of hammers no longer necessary. Grate bars also last longer. The double set of reversible manganese breaker plates, which last twice as long as other types, give four times the service! Maintenance and downtime are cut 50% or more.

Get all the facts about the hammer mill with *ALL* the top features.

WILLIAMS PATENT CRUSHER & PULVERIZER CO. • 2706 N. Ninth St. • St. Louis 6, Mo.



WILLIAMS
CRUSHERS GRINDERS SHREDDERS
Oldest and Largest Manufacturers of Hammer Mills in the World



To assure permanent support for this seawall on Lake Michigan, a Wisconsin building contractor wrapped his anchor rods in Polyken tape. Even with an abrasive backfill of wet cinders and ashes, this builder knows Polyken will prevent corrosion and help protect buildings behind the wall.

with permanent Polyken

The durable, doubly thick adhesive of Polyken tape seals all voids—seals out corrosion

Tough, long-lasting Polyken Protective Coatings keep air and moisture from the metal. And abrasion has little effect.

Try Polyken in your plant. Get complete protection for your pipes, conduits, rods—almost anything cylindrical. Polyken is made of an inert polyethylene, with an unplasticized, non-drying film. The unusually high adhesive bonds the coating to clean surfaces without a primer.

Maintenance costs are considerably lower than with paint. Polyken goes on quickly, economically, right from the roll. No heat, no solvents or thinners, no drying or clean-up time. And keep in mind Polyken's lower water vapor transmission rate, higher electrical insulation resistance and better cold-weather handling and durability.

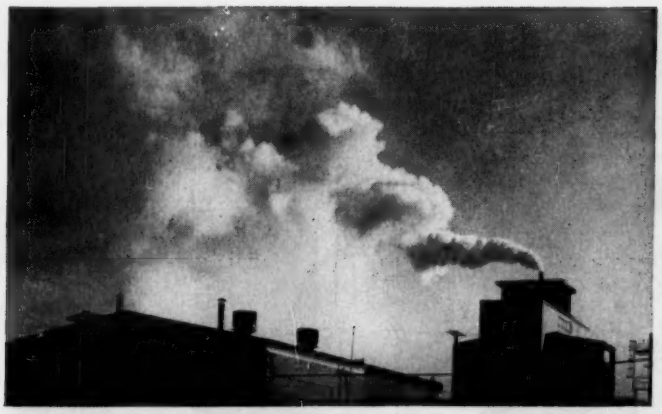
©1960 The Kendall Company

See your Polyken representative or call the Polyken tape coating distributor near you. Or simply write Polyken, 309 West Jackson Blvd., Chicago 6, Ill. (In Canada, write Polyken, Curity Ave., Toronto.)

Polyken®

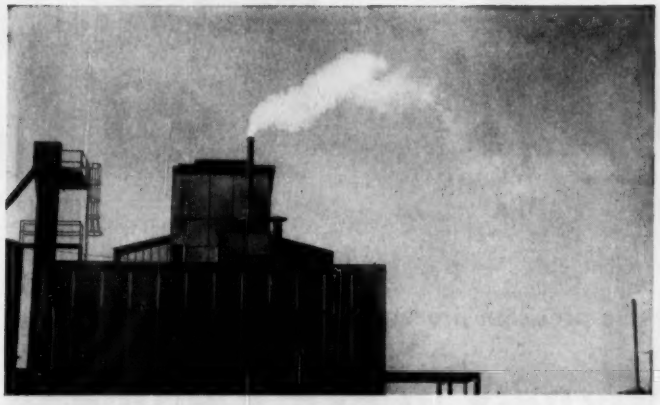
EXPERIENCED IN PROTECTIVE COATINGS

THE KENDALL COMPANY
Polyken Sales Division



Before scrubber was installed —visible cloud is composed largely of water with about 0.5% sulfur trioxide

THE CHEMICO VENTURI SCRUBBER MAKES THE BIG DIFFERENCE



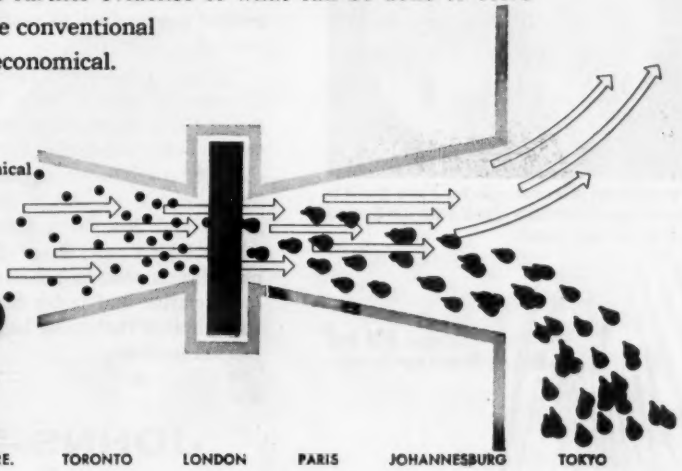
After scrubber was installed— water vapor has diminished considerably, sulfur trioxide content is practically nothing

With sulfur trioxide fumes being vented to the air in a thick vapor fog, Ansul Chemical faced an air pollution problem common to many chemical producers. They were willing and anxious to comply with community requests for pollution control, but they were unable to find a scrubber which could rid the stack of both the water vapor and the SO_3 as well.

While virtually any scrubbing device was capable of removing the water vapor, only the Venturi scrubber was effective in removing the acid fumes. By removing all but the last traces of SO_3 the Venturi scrubber gave further evidence of what can be done to solve really tough gas cleaning problems where conventional cleaning devices prove ineffective or uneconomical.

FULL DETAILS AVAILABLE

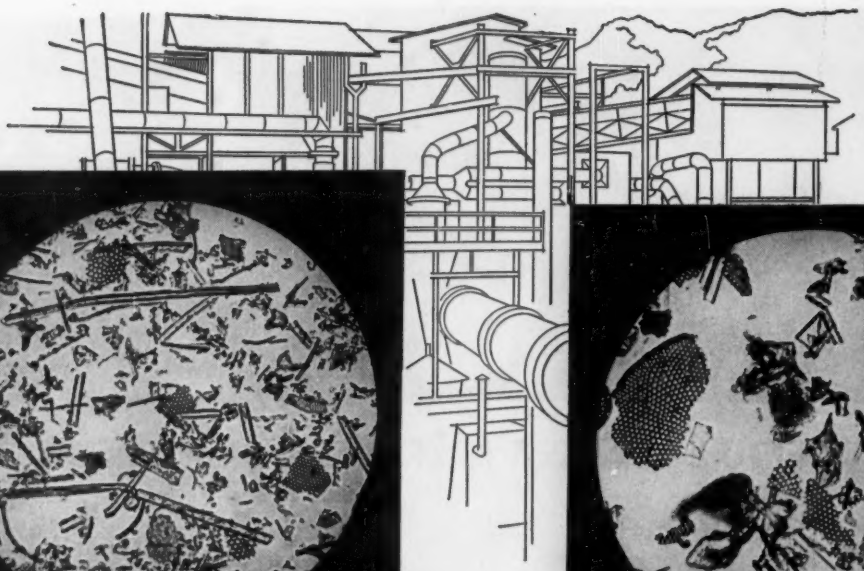
For your copy of a brochure giving complete data on Chemico Venturi gas scrubbers, or for technical assistance on a specific problem, write to Chemico at the address below.



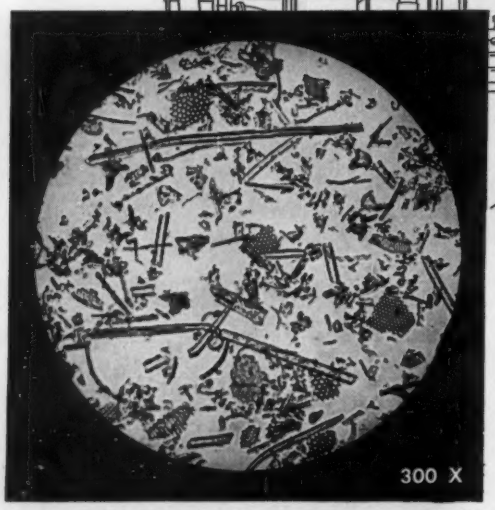
CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
Gas Scrubber Division
525 West 43rd Street, New York 36, New York

CHICAGO DALLAS HOUSTON PORTLAND, ORE. TORONTO LONDON PARIS JOHANNESBURG TOKYO



Milling and calcining equipment used for all Celite grades.

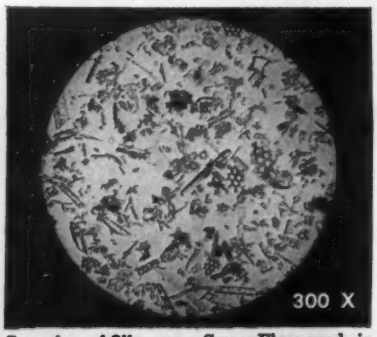


For high-clarity filtration of most liquids—use this specially milled diatomite, Hyflo Super Cel.

For filtration of larger suspended particles—Celite 545 combines maximum clarity plus faster flow rates.

In diatomites, Johns-Manville precision processing works for you

Constant uniformity in every grade of Celite assures consistent results, less down-time



For mineral filler use—Super Floss grade is made up of carefully sized fines air-floated off in the bag house.

Typical J-M bag house equipment.

As the microscope shows, each grade of Celite* diatomite has its own distinctive particle size distribution. Yet no matter where or when purchased, each remains uniform from bag to bag—your assurance of top production results with minimum down-time.

Three examples of flux-calcined Celites are shown here. Hyflo® Super Cel is widely used for filtration in many industries. It has just the right combination of coarse and fine particles to assure optimum clarity and flow rates. Celite 545, with a higher percentage of coarse particles, is used to achieve maximum clarity and faster flow rates with liquids that have larger suspended particles.

Super Floss, one of several bag house grades, has fine particle size distribution. A white powder, it is processed within very narrow tolerances (less than 1% retained on 325 mesh). It is a popular filler in fine products such as silver polishes.

Johns-Manville can precision-produce so many different grades of Celite because it mines the material from the world's largest and purest commercially available deposit. For assistance with specific filtration or mineral filler problems, talk to a nearby Celite engineer. Or write direct to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

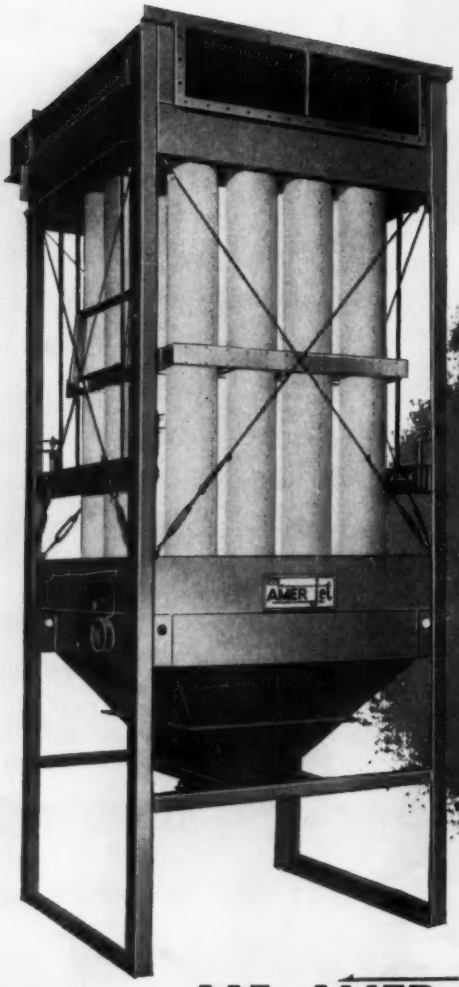
JOHNS-MANVILLE JM

WHEN YOU BUY TIMKEN® STEEL PRESSURE TUBING, you're sure of fine forged quality in the tube itself and an exceptional inner surface that assures maximum tube life per dollar.

For almost every condition of corrosion, pressure or temperature, there's a Timken seamless steel pressure tube. Timken seamless tubing is available in all common carbon, alloy and stainless grades, up to 11" O.D. and with wall thickness up to 3¼".

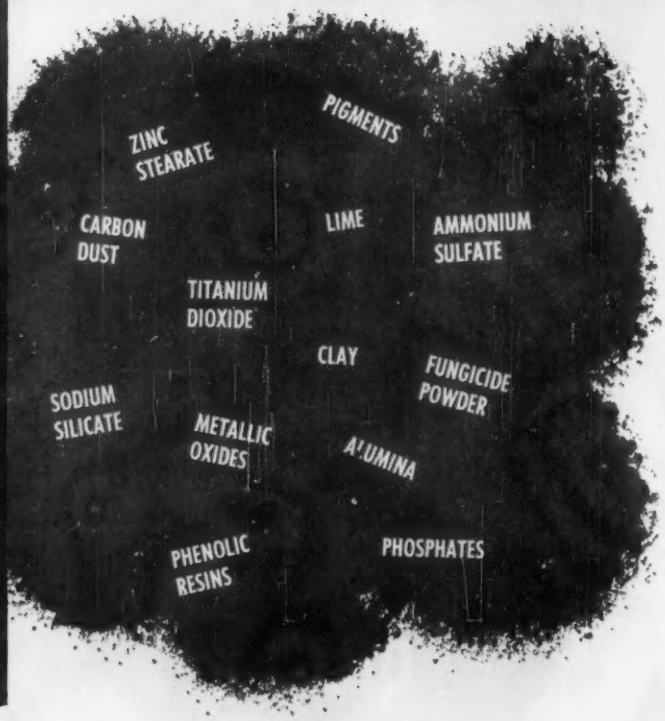
Our expert metallurgists will be happy to work with you to help you select the one tube that will give you maximum tube life per dollar. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

TIMKEN®
FINE ALLOY STEEL



Do you have a

DUST PROBLEM?



AAF AMERjet DOES MANY JOBS FOR CHEMICAL PROCESSORS

If your operations require *complete dry dust recovery;* and collection of the *very finest* particles, you've got a job for AMERjet. *Higher efficiency, lower service cost and smaller space requirements*—three good reasons for turning your critical dust collecting jobs over to this remarkable fabric arrester.

Constant air volume is assured by the automatic continuous re-conditioning of the fabric tubes. Reverse jet principle allows velocities through the media up to *five times greater* than ordinary fabric collectors. The compact, factory-assembled AMERjet is easily erected on the job at minimum cost.

AMERjets are available for handling *any* exhaust volume. For complete information, call your local AAF representative or write direct for Bulletin 279. Address: Mr. Robert Moore, American Air Filter Co., Inc., 326 Central Avenue, Louisville, Kentucky.

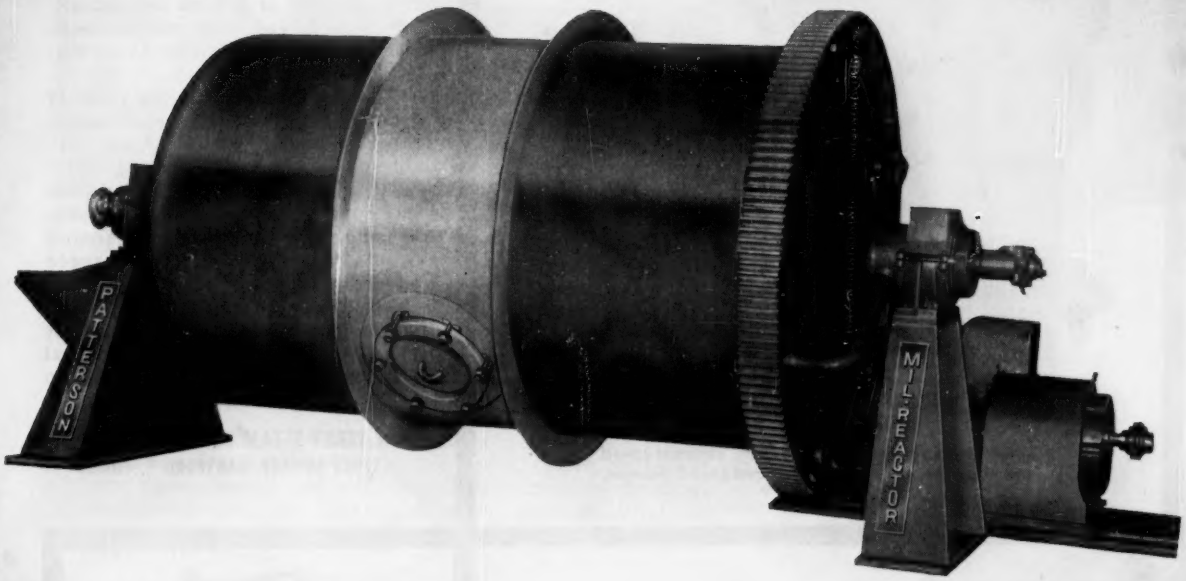
AAF **American Air Filter**

BETTER AIR IS OUR BUSINESS

NOW...Reacting...Extracting...Drying...
Grinding...Thermal Reacting...
Blending...Wetting...Dispersing...

in the ALL-IN-ONE

PATTERSON *Mil-Reactor*



A COMPLETE PROCESS UNIT, replacing separate reactor, blender, dryer, grinder and solvent extractor, bringing unparalleled savings in first cost, operating cost, space, time and labor!

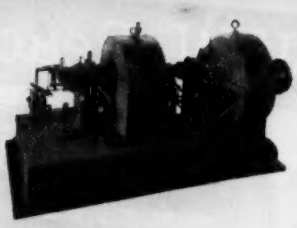
The Patterson Mil-Reactor provides size reduction with mass transfer or chemical kinetic operations. It provides gas blanketing during solid-solid or liquid solid operations . . . simultaneous addition of liquids, with vapor addition or removal . . . precise control of temperature . . . concurrent or countercurrent liquid-solids flow . . . batch and in many cases continuous operation.

In every operating characteristic, this new processing unit brings hitherto unobtainable efficiency in utilization. It is a tool of tomorrow for the chemical industry, ready for your advanced demands of today. Let us send you the remarkable Mil-Reactor story—and make any desired pilot studies for you in our high temperature test facility. *May we have your inquiry?*

THE *Patterson* FOUNDRY AND MACHINE COMPANY

EAST LIVERPOOL, OHIO

There's a Terry solid-wheel turbine for any mechanical-drive requirement



Solid-wheel turbo-geared unit rated 600 hp, 4000/650 rpm.

Standard solid-wheel turbine with constant-speed mechanical-type governor and hand speed changer.

The completeness of the Terry line of solid-wheel turbines enables you to choose an *ideal* drive for any application . . . choose the specific features you want from a wide variety of designs.

Standard turbines are made in capacities up to 2,500 hp, with either cast-iron or cast-steel casings. The standard wheel is carbon steel. Where operation is to be at high speed or at high temperature, wheels of forged alloy steel are used. Vertical and geared turbines are also available.

And you can select from a range of governors, including: constant speed, either mechanical or oil relay, and variable speed, either direct acting or oil relay. Excess-pressure or constant-pressure pump governors are also available. When required, remote speed control can be furnished for variable-speed governors.

Tell us what your requirements are so we can send you full details of a turbine to meet your needs exactly. For general information, send for a copy of bulletin S-116.

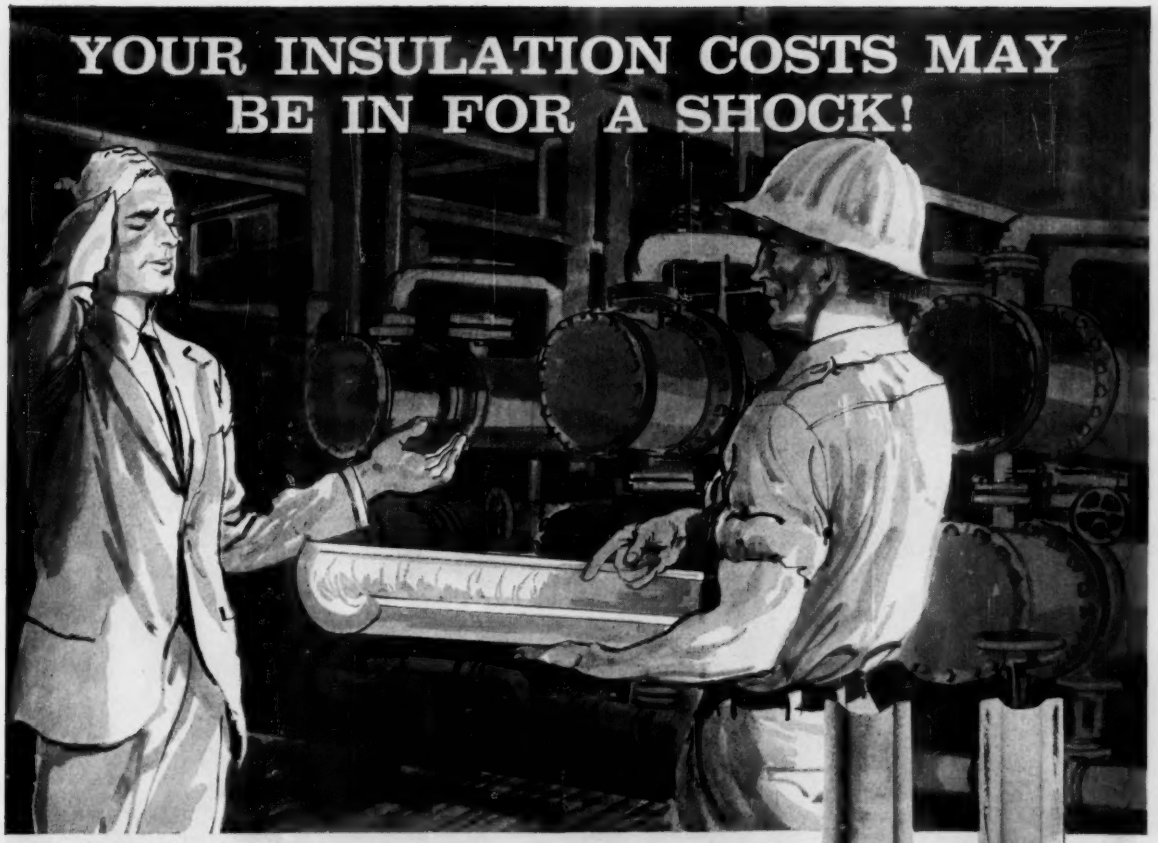
THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

TERRY

Vertical turbines with the Terry solid wheel are available in capacities from 5 to 300 hp.

TT-1218

YOUR INSULATION COSTS MAY BE IN FOR A SHOCK!



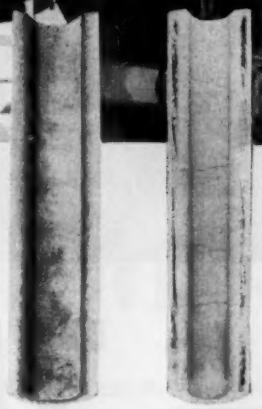
use Unibestos to eliminate thermal shock effects

Insulation that looks perfectly intact on the outside is sometimes a maze of cracks on the inside. That's when your operating costs, in the form of *heat losses*, begin sailing off into thin air. And it's thermal shock effects like this that can put the real shocker on your operating costs.

But you won't find thermal shock effects in any section of Unibestos insulation. Unibestos defies thermal shock, fumes, acids and moisture; resists impact and rough handling; eliminates shrinkage; cuts application time and costs; and guarantees real insulating efficiency. That's why it's worth more. Yet it continues to sell at competitive prices.

Available in full range of standard pipe sizes and thicknesses. Single thicknesses to five inches. Specials to 44″ O.D. in half sections.

Write today, on your letterhead, for Bulletin No. 65610.



UNIBESTOS AMOSITE INSULATION 900° F.

EFFECTS OF THERMAL SHOCK

Exclusive use of extra long *Amosite* asbestos is your positive assurance that Unibestos insulation has the mechanical qualities that prevent thermal shock effects. Guaranteed up to 1200° F, Unibestos has been known to withstand temperatures as high as 2000° F, without thermal shock effects.

UNIBESTOS

worth more, yet sold at competitive prices

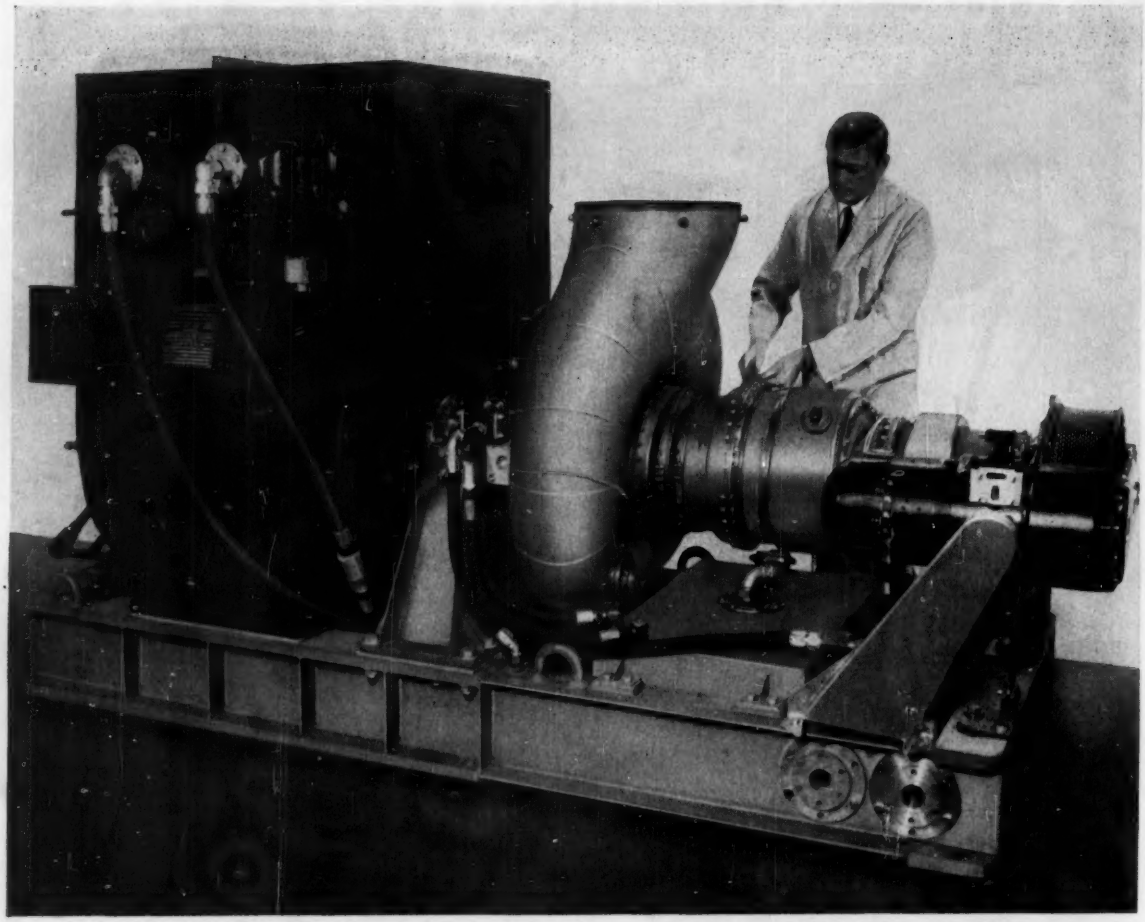
UNARCO®

UNARCO PRODUCTS

• UNIBESTOS, Amosite Asbestos Pipe Covering and Block • Calcium Silicate Pipe Covering and Block • 85% Magnesia Pipe Covering and Block • Mineral Fiber Block • Wrap-On Insulation • Lace-On Insulation • Turbine Blankets • Insulating and Finishing Cements • Asbestos Textiles • Packing and Gasketing.

UNION ASBESTOS AND RUBBER COMPANY • FIBROUS PRODUCTS DIVISION

DEPT. 259, Bloomington, Illinois



750 KW!

Electrical generator driven by new Solar Saturn *industrial gas turbine offers unequaled fuel efficiency, outstanding performance*

SOLAR'S REMARKABLE NEW 1100 hp industrial gas turbine sets new standards of performance as a power source for marine and industrial generators. The engine is extremely lightweight, averaging 1/10th the weight of conventional engines of similar horsepower. It occupies only 51 cubic feet. It starts instantly (an advantage of significant importance in generator applications). And it takes full load without laboring, even after long periods of standby service. In addition, Solar's *Saturn* industrial gas turbine offers fuel efficiency unequaled in its field.

As a dependable power source for generators and compressors, as a propulsion unit for high-speed boats and in other applications... Solar gas turbines are saving time and money. For information about Solar's family of 50 to 1100 hp gas turbines, write to Dept. H-184, Solar Aircraft Company, San Diego 12, California.

SOLAR
AIRCRAFT COMPANY
A subsidiary of International Harvester Company

Before Buying Any Valve

ASK THESE QUESTIONS

1. Will It Perform More Effectively In The Service?
2. Where Will It Save Money?
3. How Practical Is The Design?

jamesbury "Double-Seal"™ BALL VALVES*

As Versatile As Industry Itself!

PROVIDE THE RIGHT ANSWERS

1. The "Double-Seal" Ball Valve has PROVED more effective in handling a wider range of liquids and gases than any other valve.
2. The "Double-Seal" Ball Valve requires no lubrication. Special design permits valve stem to be removed for repacking while valve remains in line full-open or full-closed. Resulting savings on maintenance are significant.
3. The "Double-Seal" Ball Valve design is the original ball valve design engineered to give more control, full pipeline capacity and minimum friction loss.

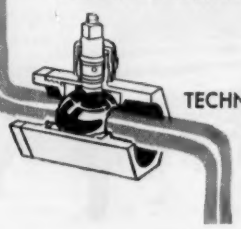
Widest Range of Sizes and Materials Available

METAL VALVES		PLASTIC VALVES	
TYPE	SIZES	TYPE	SIZES
Screwed End Flanged	¼" thru 3" ½" thru 10"	Screwed End Flanged	½" thru 3" ½" thru 4"

Jamesbury "Double-Seal" Ball Valves are available in Types 303, 316 and Alloy 20 Stainless Steels, Carbon Steel, Bronze, Ductile Iron, Aluminum and PVC. Other materials on special order.

Interchangeable seats and seals are available in "Teflon", Nylon, Buna-N, Neoprene, Hypalon and natural rubbers.

Pneumatic, Hydraulic and Electric Motor Operators to fit Remote Control Requirements.



COMPLETE TECHNICAL INFORMATION ON REQUEST

* PATENTED

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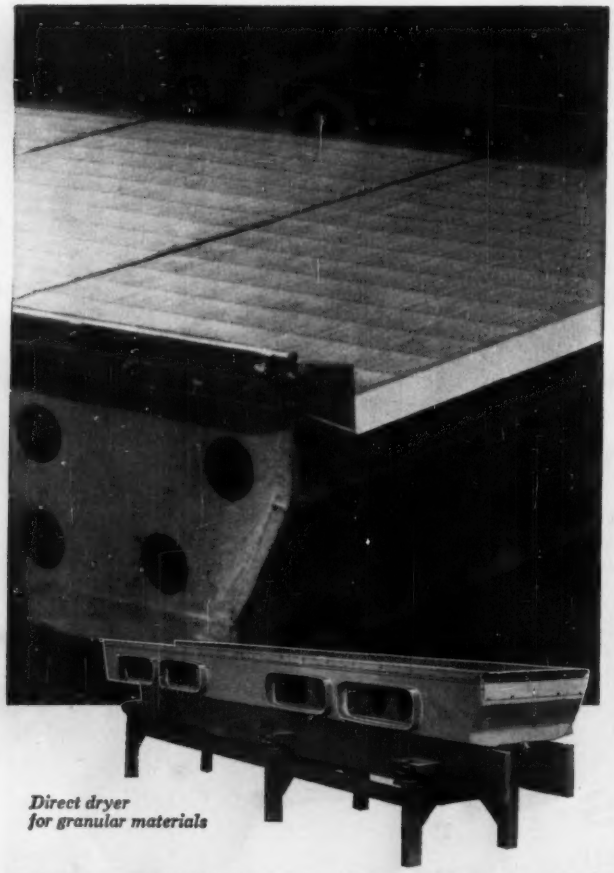
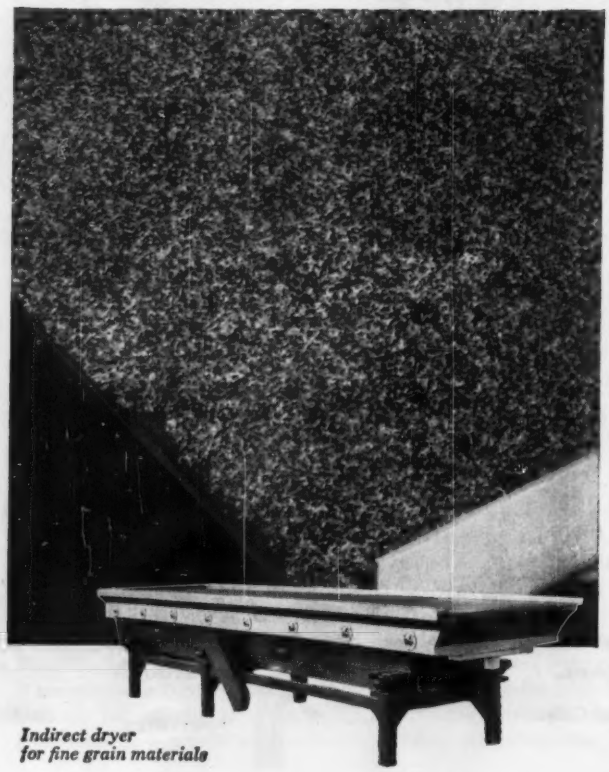
JAMESBURY CORP., Worcester, Mass.

Distributors in Principal Cities

0134



Direct dryer for granular materials



Indirect dryer for fine grain materials

Continuous drying or cooling at less cost!

New Jeffrey units feature variable-amplitude mechanical vibrating drive

Now proved in service, Jeffrey's new line of mechanical drive dryers is demonstrating lower maintenance and operating costs, in addition to savings in initial investment. Yet these dryers offer the same operating advantages as electric vibrating systems—variable amplitude drive permits adjusting speed of travel and depth of material as desired. Operation is fully automatic; heat transfer is fast and efficient.

These machines may be used for either drying or cooling and are available in direct or indirect types. They are built in standard lengths of 10 or 20 feet. A tailor-made installation can be assembled from standard components.

The direct dryer is designed to carry granular materials, in the range of ¼" down to about 60 mesh, on a stainless steel conveying surface through which drying air or gas is passed. The indirect type dryer carries very fine grain materials on a solid plate conveying surface, heated from below by low pressure steam or heated air.

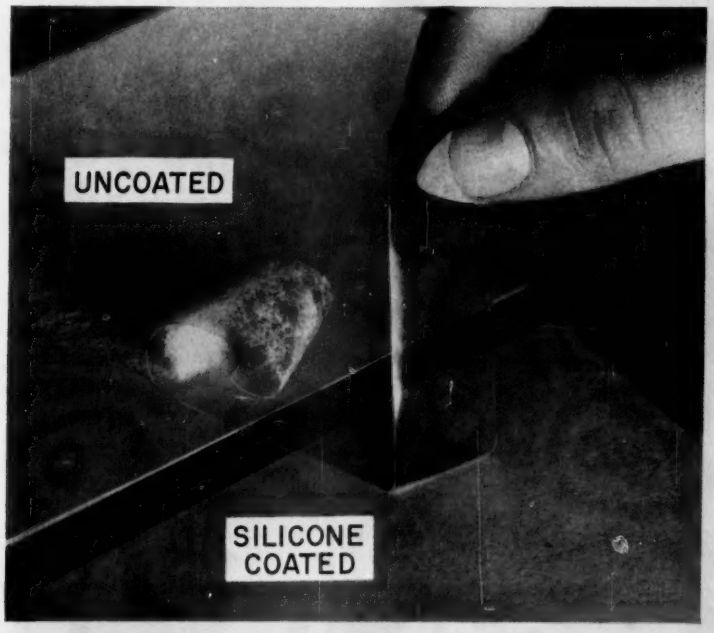
Investigate this new cost cutter. For information write, The Jeffrey Manufacturing Company, 909 North Fourth Street, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT
...TRANSMISSION MACHINERY...
CONTRACT MANUFACTURING

SILICONE NEWS from Dow Corning

No Sticking Here!



New Silicone Coatings for Paper End Sticking; Save Time, Money

Sticky products like asphalt, dates, and uncured rubber have always been troublesome to pack, unpack or process. But that's all in the past for people who specify new Syl-off® silicone coatings for paper.

Even the stickiest materials are easily and cleanly removed from shipping containers made with Syl-off coated paper or paperboard. And there's nothing to compare with the ease of removing Syl-off coated separators from pressure-sensitive backed items — labels, decals, wallpaper . . . backing papers peel completely free without tearing. Syl-off coatings won't transfer or migrate, either . . . which means you can use coated papers as package wraps, liners and interleaving for food products.

WHO BENEFITS? You do! If you buy and use sticky materials, Syl-off means faster in-plant handling and processing. You get all the material you pay for and product losses are minimized. If you ship sticky products, Syl-off helps you create the kind of happy, satisfied customers who make the difference between profit and loss. You can actually save money, too, because Syl-off brand coatings weigh less than other release coatings which means lower shipping costs.

GETTING PERSONAL. Are sticky products giving you or your customers trouble? Can Syl-off help? Syl-off coated papers or containers can be engineered to your special needs by experienced mills and converters. Write now for list of Approved Sources. Address Dept. 1812.

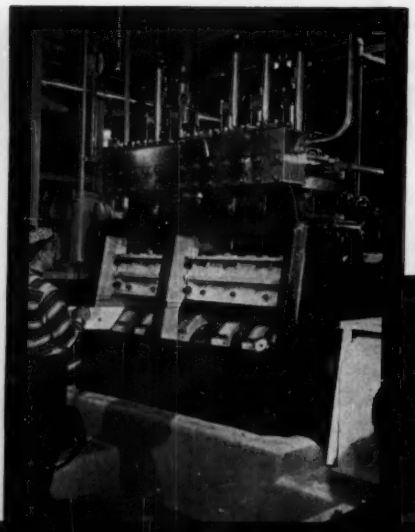
Now Available: New Brochure— "How Silicones Serve the CPI" Write Dept. 1812.

first in silicones

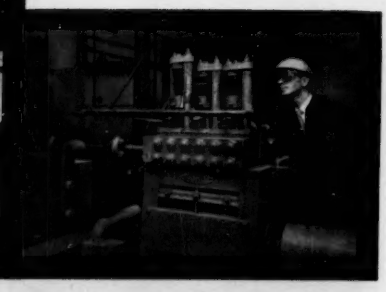
Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

WHAT'S YOUR SPECIAL PROBLEM IN PUMPING?

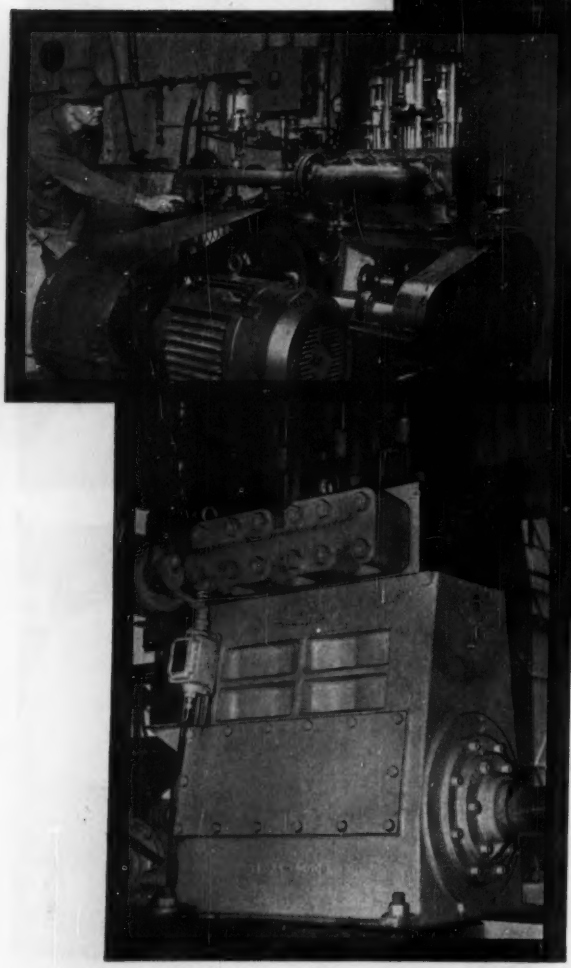


Special nylon ball valve and stainless steel fluid end handle silica gel at 1800 psi.

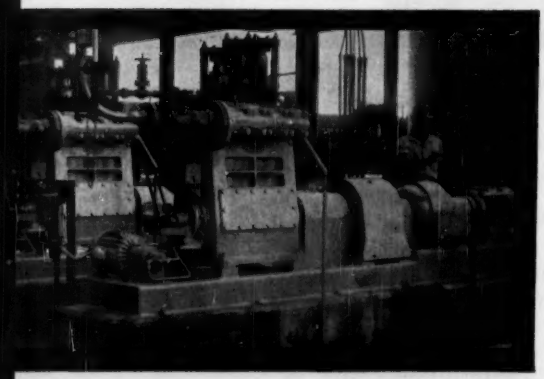


This Aldrich pump handles highly corrosive chemicals—both alkaline and acidic.

Here, Aldrich pumps continuously control the flow of liquid ammonia at 3700 psi.



Aldrich pumps with nickel alloy fluid end pump 50% caustic soda solution at 400 psi.



To handle, alternately, caustic and brine, at 3000 psi, this Aldrich Triplex pump has entire fluid end of Monel.

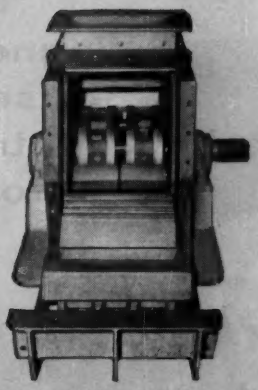
Corrosives? Slurries? High pressures? High temperatures? We'll find the answer!

All pump companies sell pumps. And all have their share of pumping problems. At Aldrich, our most important stock in trade is our ability to solve the rough pumping problems of the process industries. We've had over 50 years of working with chemicals and chemical processes. We know the problems of pump wear; of temperature, corrosion, viscosity; and your need for sustained pump operation. We study all the factors in your problem, in depth . . . and come up with a *better* answer, not merely *an* answer. For information on capacities, pressures and sizes, see our insert in *Chemical Engineering Catalog* or write for reprint (Data Sheet 100). ALDRICH PUMP COMPANY, 3 Gordon Street, Allentown, Penna.

The tough pumping problems go to ALDRICH

CRUSHING LIGHT AND ABRASIVE MATERIALS?

Pennsylvania CDL Series Reversible Impactors offer 5 unique advantages



• Pennsylvania CDL 5-32 Reversible Impactor with breaker block assembly open to show easy accessibility.

This is the crusher designed specifically for jobs where weight and ruggedness are unnecessary —such as crushing light and often abrasive materials. To plant operators with such job requirements Pennsylvania CDL Series offers:

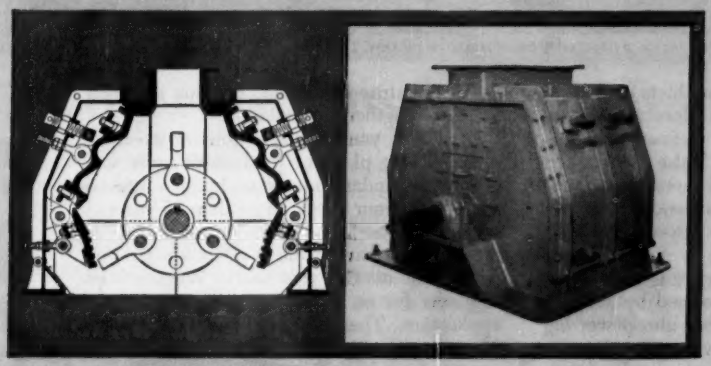
1. Definite wear advantage accomplished by use of cast alloy steel in all hammers and breaker blocks. Side liners are of heat-treated carbon steel.

2. Adjustable upper and lower breaker blocks. In some series the upper blocks are reversible. Maximum control of circulating load and product gradation is achieved by merely moving upper and lower blocks closer to or further from the hammer circle.

3. Easy accessibility. The entire upper and lower breaker block assembly swings back, exposing the entire rotor assembly, thus holding maintenance time to a minimum.

4. Identical reduction. With breaker blocks located on both sides of the machine, and feed chute directly over center of the rotor, these units perform identical reduction when run in either direction.

5. Balanced wear. Systematic rotor reversal balances wear on both sets of breaker blocks and eliminates hand-turning of hammers—a major saving in maintenance costs for both parts and labor.



• Pennsylvania CDL 7-38 Reversible Impactor

FREE BULLETIN

For full description of Pennsylvania CDL Series Impactors, as well as other Pennsylvania Reversible Impactors, write for Bulletin 6018.

PENNSYLVANIA CRUSHER DIVISION
BATH IRON WORKS CORPORATION
WEST CHESTER, PENNA.

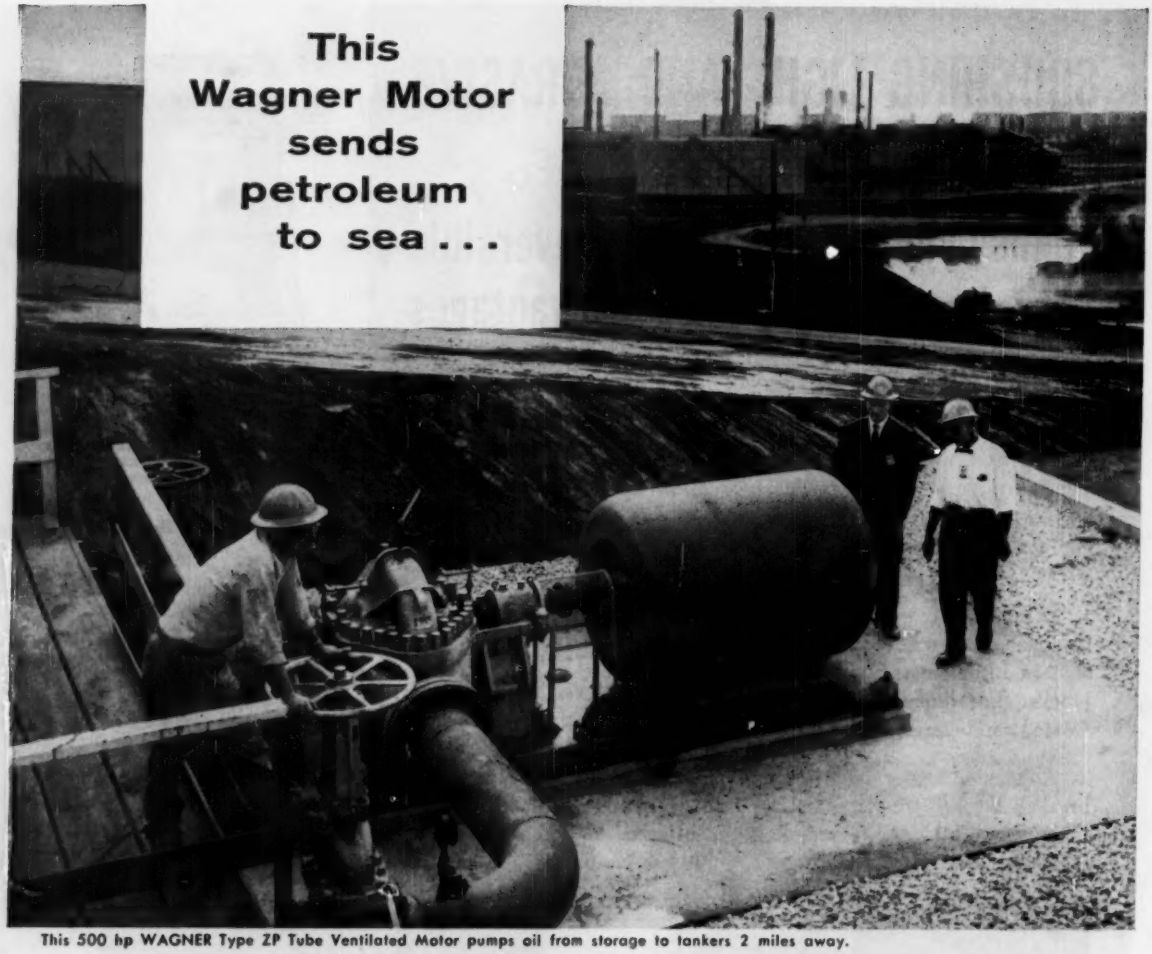
★ ★ ★

Over 50 years' concentrated experience in all types of material reduction makes Pennsylvania your best source of crushers and engineering advice and service. Call on Pennsylvania with your next crushing problem. Representatives from coast-to-coast.

PENNSYLVANIA CRUSHERS

BATH-BUILT

This Wagner Motor sends petroleum to sea . . .



This 500 hp WAGNER Type ZP Tube Ventilated Motor pumps oil from storage to tankers 2 miles away.

Big job, moving petroleum products to market. Standard Oil of California does it well . . . helped, at its El Segundo Refinery, by this 500 horsepower Wagner Tube Ventilated Motor. This explosion-proof motor's job: provide the power to pump crude oil from storage tanks down to the sea—and waiting tankers—two miles away.

Starting oil on a bon voyage is just one of many heavy-duty jobs performed by Wagner Tube Ventilated Motors. They also power big fans, blowers . . . any heavy-duty application that must be operated for long periods of time without a shut down.

These motors have fabricated steel frames that contain a series of tubes (as shown in photo below) through which cooling air is forced by an external blower. Internal blowers, one at each end of the rotor, circulate the warm air inside the motor through ducts in the rotor and stator and around cooling tubes. This effective cooling system holds the operating temperature of the motor within specified limits to lengthen motor life.

Whatever your motor requirements—large or small, for plant or product—Wagner can supply a standard motor or build a special motor to fit your needs. More than 65 years of constant research and development in electric motor design have made Wagner a name you can depend on. Call your nearby Wagner Sales Engineer for an analysis of your next motor application. There are Wagner branches in 32 principal cities.

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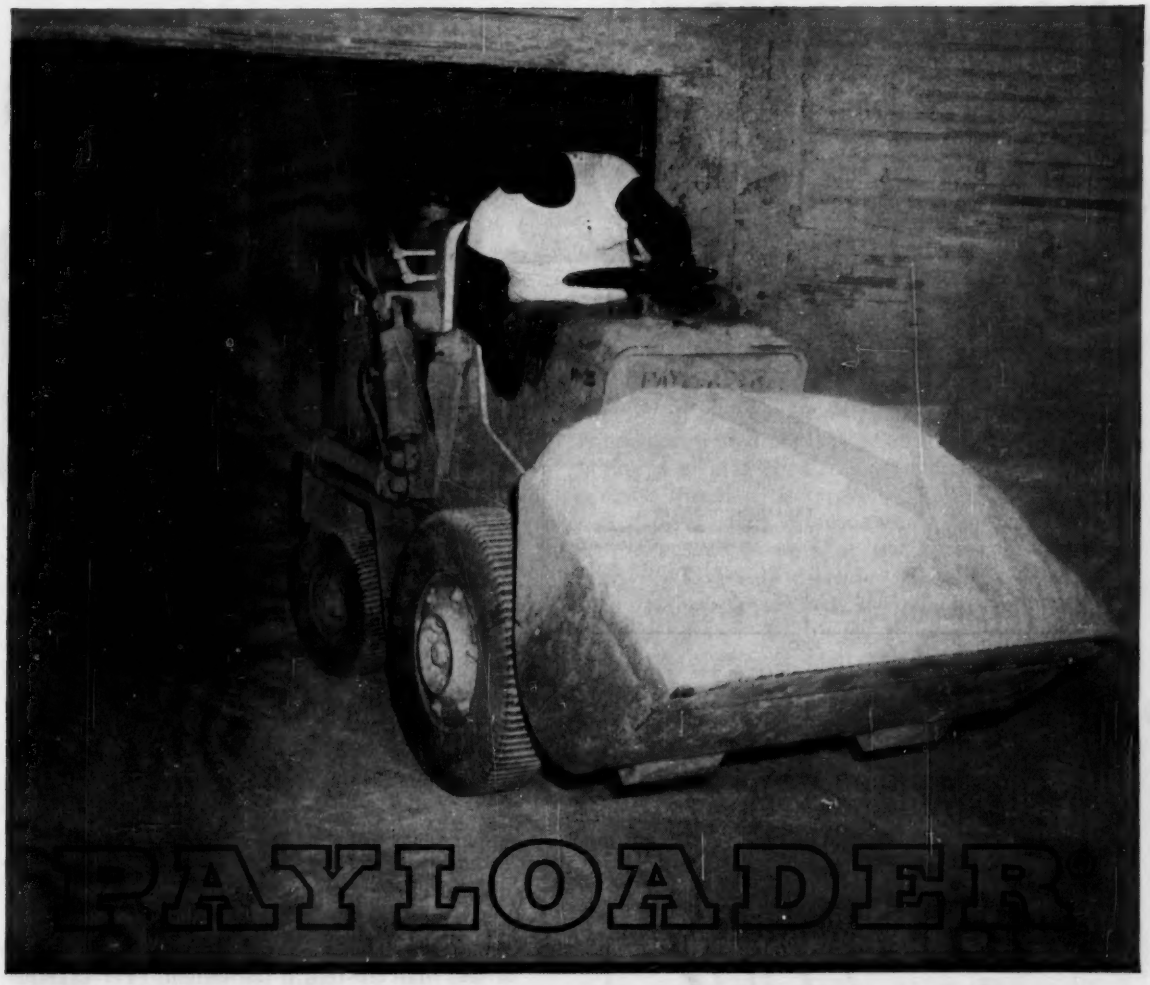
WM60-11

SERVING 2 GREAT GROWTH INDUSTRIES—*ELECTRICAL • AUTOMOTIVE*



"H-25 proved its production efficiency...

over the other machines during the competitive demonstration we held before we purchased it", says R. P. Reinke, Plant Superintendent of Florida East Coast Fertilizer Co., Homestead, Fla. "We have been PAYLOADER users for nine years, with all-around satisfactory service. Our first unit, a Model HA, is still in service. Our present fleet consists of three HA's, and the new H-25 that has now completed its first season with only normal maintenance. This new design is 20% more productive due to power-shift, power-steer, faster loading speed, better load control, less spillage and faster delivery."

Owners' reports on the H-25 praises its high output, dependability and low maintenance. Mechanical excellence and extraordinary protection against dust and dirt are the two basic reasons for this.

Mechanical Excellence includes the Hough power-shift transmission — exclusive in its class with two speeds forward and reverse; power-steer; power-transfer differential; 4,500 lbs. breakout force; 2,500 lbs. operating capacity; shortest turning radius of only 6 ft.

Extraordinary Protection includes triple air cleaner system; cartridge-type filters on all three oil systems; sealed self-adjusting hydraulic brakes; enclosed parking brake; special grease and oil seals on all vital points. Your Hough Distributor wants to show you what this tractor-shovel can do. See him soon, or return coupon.

HOUGH®

THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY - INTERNATIONAL HARVESTER COMPANY

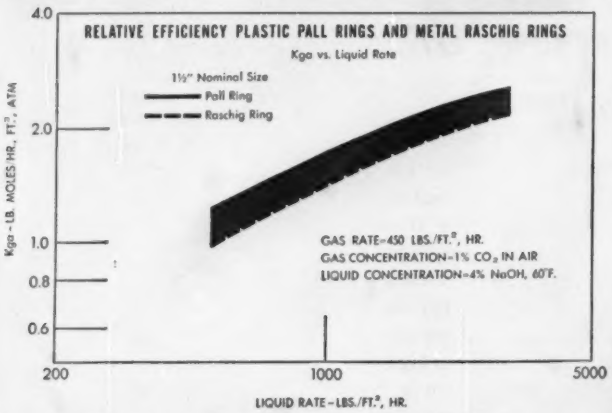
HOUGH, PAYLOADER, PAYMOVER, PAYLOGGER, PAYLOMATIC and PAY are registered trademark names of The Frank G. Hough Co.

THE FRANK G. HOUGH CO., 754 Sunnyside Ave., Libertyville, Ill. 12-A-1

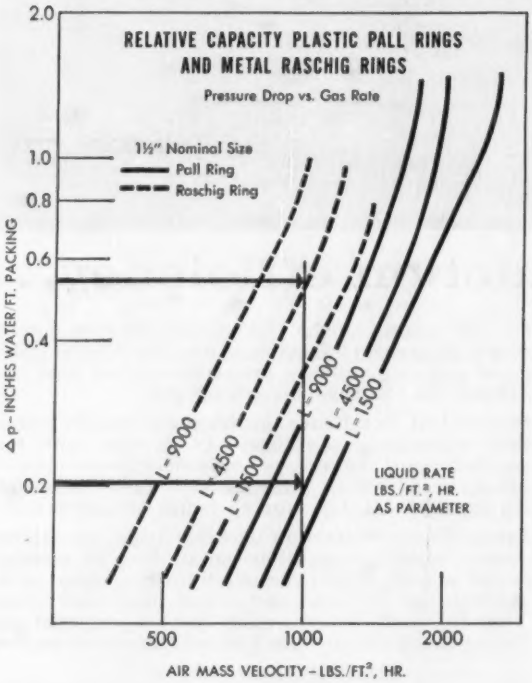
Send data on PAYLOADER units and the many attachments.

NAME
TITLE
GOVT'L UNIT
STREET
CITY STATE

HIGH CAPACITY HIGH EFFICIENCY PALL RINGS in PLASTIC



Kga data, obtained in one of our 30" experimental towers, reflects the much greater efficiency of plastic Pall Rings.



Pressure drop data likewise reflects the high capacity of plastic Pall Rings. For example, pressure drop through metal Raschig Rings at a gas rate of 1000 lbs./ft.², hr., and a liquid rate of 4500 lbs./ft.², hr., is almost three times greater than through plastic Pall Rings.

The remarkably efficient Pall Ring, first introduced on the American market in 1957, in metal, is now available in polypropylene and high density polyethylene;* in four sizes: ⅝", 1", 1½" and 2".

Pall Rings in plastic offer the same striking advantages of low pressure drop and high capacity at less than one-fourth the weight. (For example, 1½" Pall Rings in carbon steel weigh approximately 23½ lbs. per cu. ft. In plastic, only 4¼ lbs.)

Take a look at the graphs showing comparative efficiency data and capacity data for metal Raschig Rings and plastic Pall Rings . . . data prepared from test runs in one of our 30" diameter experimental towers. The differences stem entirely from the characteristics of the two rings. In the Pall Ring the inner projections of the wall become active working surfaces as opposed to the relatively "dead" inner wall of the Raschig Ring.

The conclusions are inevitable: tower volume can be substantially reduced by using Pall Rings (either metal or plastic) in place of Raschig Rings.

***On special order, Plastic Pall Rings can also be supplied in PVC and polystyrene.**

OUR 101st YEAR

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Top news stories and what they mean to CPI technical decision–makers

Chementator

Warning! Nitrobenzene, nitric acid and water can be explosive mixture

Without revealing any details of a secret process for making aniline, officials of Tennessee Eastman's Kingsport, Tenn., plant have issued a warning to industry concerning a chemical mixture believed to have triggered the explosion that wrecked the Kingsport aniline facility, killing 15 workmen.

The announcement:

"It is believed that the explosion . . . was the detonation of a mixture of nitrobenzene, nitric acid and water. It has been concluded that a substantial concentration of water was present at the time of the explosion. The violence of the explosion indicated that the mixture was detonated with a speed and power comparable to TNT."

Tennessee Eastman declined to comment on a *CE* query regarding the possibility that some polynitrobenzene might have formed in the nitration step (di- and trinitrobenzene are considered explosive) but emphasized that even with substantial quantities of water present, a mixture of nitrobenzene and water is very dangerous.

Allied Chemical has acquired the rights to the caprolactam process of Snia Viscosa, Milan, Italy. SV's starting material is toluene instead of phenol, the feed used by Allied—the sole U.S. caprolactam producer—at its Hopewell, Va., plant

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Success of fluorocarbon resins spurs new entry into market

Drawing upon its experience in manufacture of gaseous fluorocarbons, Pennsalt Chemicals Co. is launching a new line of fluorocarbon plastic resins. A main factor in Pennsalt's decision is the rapidly growing market that the two major fluorocarbon resins—Teflon and Kel-F—are enjoying, which is causing a concurrent growth in demand for fluorine (see p. 79).

Called Kynar, Pennsalt's new fluorocarbon is still in semicommercial stage. Kynar is a polymer of vinylidene fluoride (CH_2CHF) with a molecular weight of about 500,000. By controlling molecular weight in this range, says Pennsalt, it can produce a resin that can be extruded and molded into complex shapes on standard equipment—a characteristic Teflon doesn't possess.

Price of Kynar is now higher than other fluorocarbons because of limited production, but Pennsalt says that when volume increases, Kynar will sell for less than either Teflon or Kel-F. Kynar will compete directly with the older resins for use in fabricated parts (gaskets, diaphragms, impellers), heavy-wall pipe, tank linings and packaging for corrosive materials.

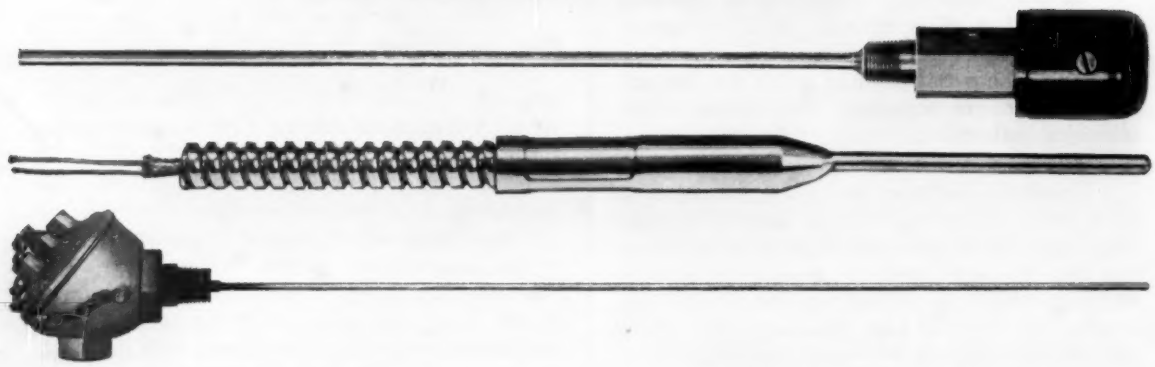
In a renewed bid to grab a greater portion of the fluorocarbon market, Allied Chemical is reintroducing its resin line under a new name—Halon. Halon is a copolymer of vinylidene fluoride and chlorotrifluoroethylene, along with unidentified materials, which give Halon a higher impact strength than Kynar. Halon, however, has lower tensile, compressive and flexural strength than Kynar.

HCl process takes another stab at winning chemicals from wood

On Kyushu, the southernmost island of Japan, Shin Nippon Chisso Hiryo Co.'s Minamata plant is piloting what the firm hopes will be an answer to the long-pondered problem of economically extracting chemicals from wood. The Japanese company has modified an old German HCl treating process to make sugars from wood, is operating a 660-lb./day pilot plant in an attempt to pinpoint the potential of the route.

The firm claims to have solved three problems that plagued the older dextrose-from-cellu-

CHOOSE FROM 150,000 STANDARD *MegopaK* SMALL-DIAMETER THERMOCOUPLES



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lose hydrolysis process: acid corrosion, HCl recovery and product refining. Patents are pending on the process, so extensive details are not available. But here is an outline of the flowsheet supplied by *CE's* Tokyo correspondent:

Raw material—sawdust—is prehydrolyzed with dilute HCl to dissolve hemicellulose. Wood particles are then treated with a small amount of hydrochloric acid, then cooled (to provide greater absorption) and further treated with gaseous HCl. To complete hydrolysis, wood contacts hot HCl gas. Further heating at higher temperature recovers all the HCl from the solid particles. The saccharified product is then hydrolyzed by heating with water and the dextrose is separated from the lignin.

Dextrose solution is decolorized by ion exchange resin, then is concentrated and crystallized. The prehydrolysis solution, after separation of acetic acid, is treated in the same fashion to obtain xylose crystals.

One main feature of the modified HCl process, claims the firm, is that the hydrolysis and recovery of HCl occur simultaneously in the gaseous phase, eliminating the need to evaporate HCl from the sugar-lignin solution.

Davison Chemical Co., Baltimore, Md., is now turning out semicommercial quantities of a new family of specialty magnesium ammonium phosphate fertilizers that contain all needed plant nutrients. Seedlings, for example, can grow directly in the fertilizer without damage to the roots.

Urea process soaks up unwanted byproduct of ammonia production

At the Oklahoma City, Okla., meeting of the American Chemical Society this month, authors Raymond Franz and Fred Applegath of Lion Oil, El Dorado, Ark., described a new urea synthesis route. Process, which has been tested in a 2-lb./day urea pilot unit, has two unusual features: it utilizes carbon monoxide (a byproduct of ammonia production) and operates at 50-300 psia. Conventional urea processes use carbon dioxide feed and pressures of 2,500-3,000 psia.

In the new reaction, ammonia, carbon monoxide and sulfur (dissolved in methanol) feed continuously to an autoclave running at about 210 F. and 300 psia. Reaction forms urea and H_2S, with unreacted ammonia and CO recycling to the autoclave. Percentage yield of urea is said to be "in the high 80's." Hydrogen sulfide must be oxidized back to sulfur prior to recycling.

Lion Oil (a Monsanto subsidiary) developed the process as a possible outlet for its byproduct CO. A rough economic analysis of the route, says the firm, indicates that the process could compete with current urea flowsheets. And some of the new sulfur-from-H_2S processes can make the route even more attractive.

Lion has also looked at related reactions, switching primary aliphatic and other amines for ammonia and has produced substituted ureas that look "very interesting." Company says it has no current plans for commercializing the process, however. Development is covered by U. S. patent 2,857,430.

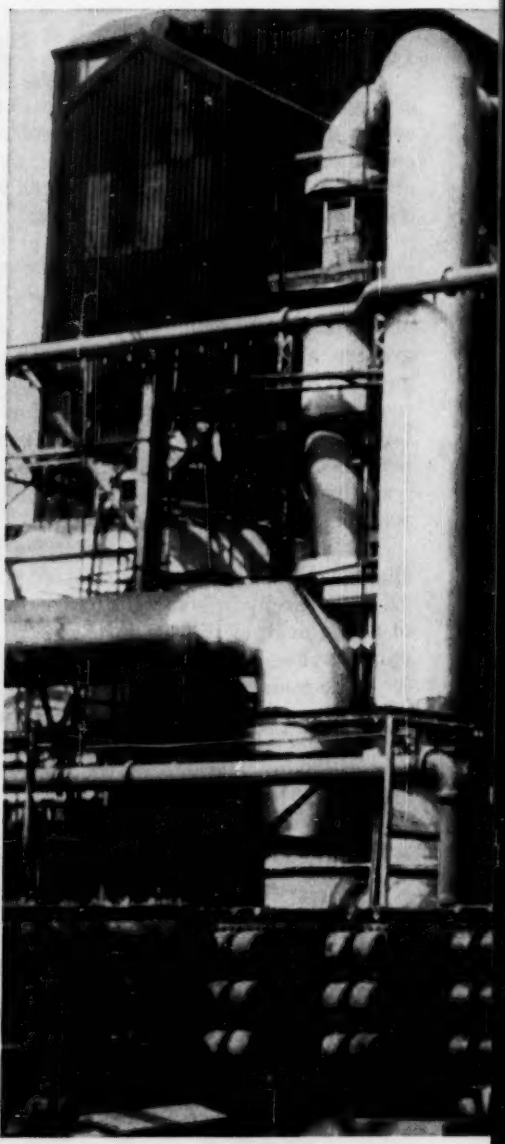
Montecatini acetylene process wins bid: it will make its debut in Texas

U. S. engineers will soon be getting their first look at a new acetylene-from-methane partial oxidation process. Diamond Alkali's acetylene plant to be built at Deer Park, Tex., (estimated capacity: 35-40 million lb./yr.) will employ the Montecatini flowsheet. The Italian firm won out in bidding that involved at least three other processes: SBA, BASF and Eastman (*Chementator*, Oct. 3, p. 35). Only plant now using the process is the company's own 20-ton/day acetylene unit at Novara, Italy.

Main advantage of the process, claims Montecatini, is a higher operating pressure (about 4 atm.) than other partial oxidation processes. This allows recovery of considerable amounts of steam for regeneration of the solvents used to purify the product gas. Another feature is the injection of gasoline into the reaction flame, utilizing heat of reaction to crack gasoline into more ethylene and acetylene. The Brno electric arc process (*Chem. Eng.*, Nov. 14, p. 120) uses a similar quenching-cracking technique.

At the Novara plant, methane and oxygen are preheated to 950 F., then charged to the reaction furnace where pyrolysis at 2,700 F. (along with the gasoline) produces acetylene and ethylene. Reacting gases are water-quenched, then filtered to remove carbon black. Gas is cooled,

(continued on page 74)



first ***ferrous sulfate decomposition*** *plant in the United Kingdom uses...*

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Once again, the versatility of the Dorrco FluoSolids System for roasting has been demonstrated at the new ferrous sulfate plant of British Titan Products Company, Ltd., Grimsby, England . . . the first plant of its kind in the U. K.

The prime contractor was Chemico; equipment and engineering for the roasting step were handled by Dorr-Oliver Company Ltd., Croydon, Surrey.

Copperas arises as a by-product in the extraction of titanium dioxide from ilmenite. In a process developed by British Titan, the copperas is converted to a dry monohydrate powder, by spray drying.

Mixed with pulverized coal or pyrites, the monohydrate is then injected into a fluid bed where it is decomposed to SO_2 gas and iron oxides.

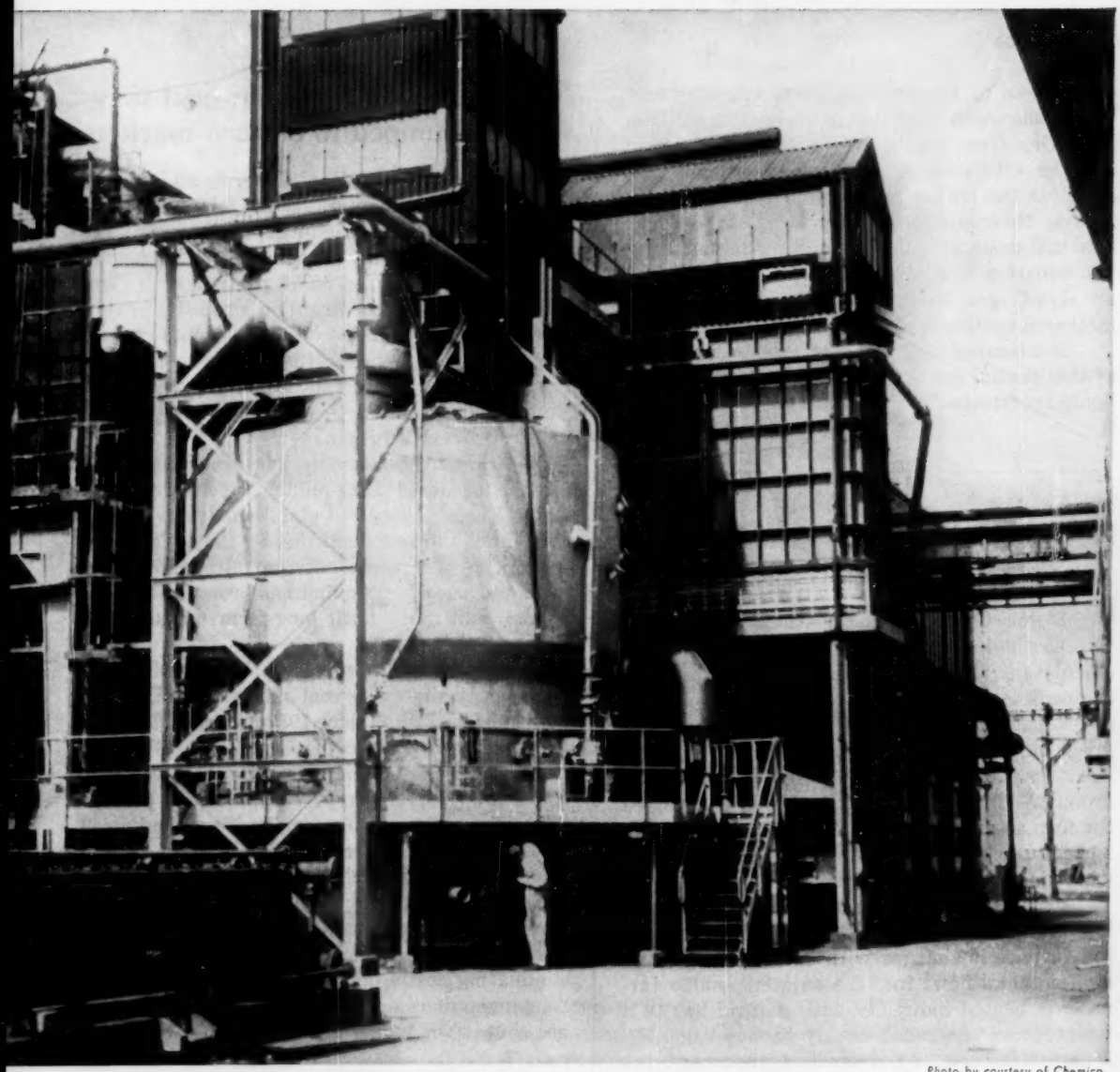

Photo by courtesy of Chemico.

The gases, on leaving the FluoSolids reactors, pass through a waste heat boiler and then on to a Chemico purification and contact acid plant to produce up to 60 tons of acid per reactor, daily. The calcine, relatively pure iron oxide, averaging 1.25% residual sulphur, can be readily sintered for use in steel making.

An alternative process, especially applicable to the treatment of steel plate pickling liquors, decomposes a wet monohydrate cake, obtained from a submerged combustion system, by first drying the cake with waste heat gases. The system offers a larger yield in acid recovery, and lower fuel costs.

For further information on the Dorrco FluoSolids System, please write to Dorr-Oliver Incorporated, Stamford, Connecticut.

What is the FluoSolids System?

A valuable tool for the process industries. When particles are suspended in an upwardly moving stream of gas, the entire dense mass behaves much like a liquid and is said to be fluidized. Applied in the Dorrco fluid bed reactor, fluidization results in a new and more efficient roasting technique, in which each particle of material is individually surrounded by a film of air or gas supplied by an external blower. A combination of reactor, blower, cyclones and other auxiliary equipment forms a complete processing system adaptable to a wide range of applications.

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compressed to 13 atm., and contacted with ammonia solution in a scrubbing tower that removes CO_2. Gas from scrubber is further cooled and sprayed with a small amount of methanol that dissolves the higher acetylene homologs. Acetylene is then absorbed in methanol at —90 F. Residual gases are subjected to low-temperature fractionation to separate ethylene, methane and an H_2-CO gas that can be fed directly to a methanol synthesis unit.

Montecatini has also developed a variation of this partial oxidation process that can utilize liquid feedstocks.

New zinc from old—and another step leads to cheaper zinc oxide

Sipi Metals Corp. has just released some of the technical details about its new 500-ton/mo. zinc oxide plant in Chicago. Developed by company engineers, its Phillips ZnO process boasts several novel features that enable the firm to cut both investment and operating costs. Plant can start with scrap zinc, produce a high quality ZnO product. Plant cost less than $300,000, enables the firm to market 99.6% ZnO initially for 13.5-14.5¢/lb., which lies between the prices of primary and byproduct grades.

Process starts with scrap zinc and die castings that have been cast into 1-ton ingots. Melting furnace is charged with several ingots, and molten metal flows into the adjacent muffle furnace, is heated indirectly with natural gas to a temperature controlled closely "above 2,000 F." Zinc metal boils in the muffle furnace and the vapor, containing traces of Pb, Cd, Fe and Cu flows upward into a fractionator.

Vapor from the top of the fractionator is nearly pure Zn; it is pulled into an oxidizing chamber, along with air, by a draft fan. Oxygen in the air flash-oxidizes the zinc to ZnO at 2,000 F. via a self-sustaining reaction. Zinc oxide fume then flows from the oxidizer to the baghouse filter through a 250-ft. flue, approximately 3 ft. in dia. Additional air is drawn into this flue to oxidize any remaining zinc and to cool the duct; temperature of the fume reaching the baghouse is only 250 F. Process produces a —325-mesh ZnO powder without pulverizing, by controlling the reaction time in the oxidizer.

Metallic zinc, brass special grade, can also be condensed by tapping the top of the fractionator. Sipi sells this material to local galvanizing shops.

No longer a pipe dream: coal may soon be pumped to eastern markets

Coal pipelining—once deemed merely an interesting theory, but now a reality in Ohio—may soon become an important factor in energy supply for the Eastern Seaboard. Texas Eastern Transmission Corp., Houston, a 50-50 partner with Consolidation Coal (Pittsburgh) in a pipelining venture, recently created a vice president's job to strengthen the hand of the man who is negotiating with eastern utilities. It's these companies that would use the coal delivered by pipeline from West Virginia.

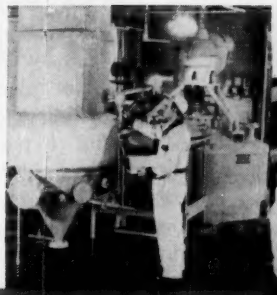
Although no schedule has been announced for the proposed $125-million pipeline project, Texas Eastern hopes to start construction next year, have the line operating in 1962. Consol is less optimistic, points out that although a firm technical basis for the line has been established, no coal can move until long-term markets are guaranteed.

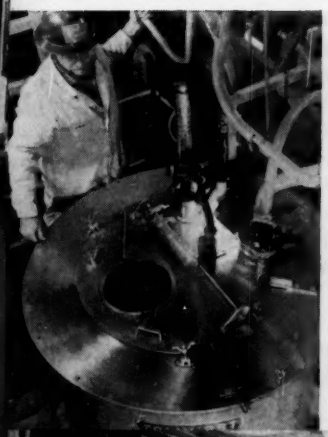
Consol's highly successful 10-in. Ohio line has been transporting coal slurry 108 mi. (from Cadiz to East Lake) since 1957 on a routine basis. Proposed 24-in. line to the East Coast (350 mi.) might depart from the older line, however, and use a new "super slurry" technique. In present operation, coal particles are dewatered and dried prior to burning. If coal is ground fine enough prior to slurrying, coal-water mixture (the super slurry) will act like a homogeneous fluid, be stored in tanks and handled like oil. With proper burner design, slurry can be burned directly, eliminating costly dewatering step. And there's no danger of coal settling in the line if pumps are shut down during a power failure.

A process to make synthetic ethyl vanillin has been devised by Rhodia, Inc., New York. Although little is known about the route, it does not start with lignin, which is the raw material used by Monsanto—the other big vanillin producer.

Secret catalyst puts a fine polish on lubricating oils by hydrotreating

British Petroleum's French affiliate, Soc. Francaise des Petroles, is building a 3,100-bbl./day





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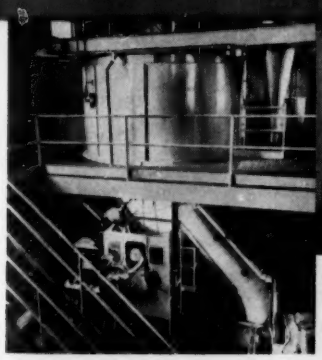

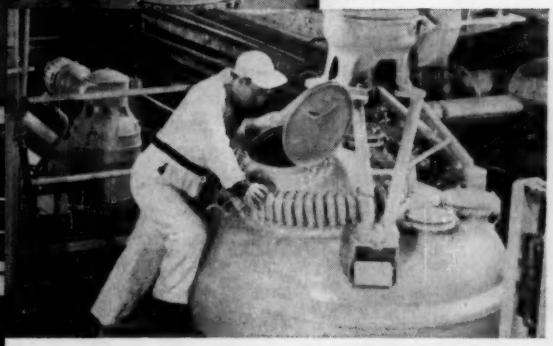

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lube oil hydrotreating unit at its Dunkirk refinery, providing the first commercial showcase for BP's new Ferrofining process. The unit will employ an unidentified "three-component" catalyst that can hydrotreat not only solvent-refined oils but also straight-distillate lubricants that normally receive acid or clay treatment.

Process is claimed to give a superior product with greater oxidation resistance than either acid- or clay-treated oils or oils hydrotreated with commercial cobalt-molybdate catalysts. Cost of the new Dunkirk installation will be about $500,000, exclusive of offsite facilities. Operating costs are said to be about 19.7¢/bbl., hydrogen consumption about 25 cu. ft./bbl.

Ferrofining is carried out at "moderate conditions of temperature and pressure." Operating pressure is lower than that of catalytic reformers, so reformer hydrogen can be used without compression. During Ferrofining, virtually no desulfurization occurs. Consequently, little H_2S is formed—allowing reactor section to be constructed of carbon-½% molybdenum steel.

In Ferrofining, a mixture of oil and hydrogen-rich gas flows through a heater where it is raised to reaction temperature, then flows down through the catalyst bed. Oil and gas leaving the reactor separate in two stages. Gas from both stages passes to refinery fuel mains while the oil is steam-stripped and dried in a vacuum column to yield the required flash point.

U. of Wisconsin has received a $97,000 grant from National Science Foundation to build an experimental chemical plant that will automatically optimize its own operating conditions. Project will be headed by G. E. P. Box and Olaf Hougen.

Cry of "foul" greets announcement that Japanese won desalting plant

"Technically unsound and legally questionable." With these provocative words, Ionics Inc., Cambridge, Mass., lashed out at the action of the Office of Saline Water (Interior Dept.) upon the announcement that a $482,000 contract for construction of a 250,000-gal./day brackish-water conversion plant at Webster, S. D., would go to Japan's Asahi Chemical Industries Co. Plant is to operate on "electric membrane" process.

According to Ionics, Asahi has no previous commercial experience in desalting brackish water as required in the bid specifications put out by OSW, and the plant as designed will not operate at required capacity on the particular water at Webster because of scaling.

Unperturbed at the charges, OSW's director, Dr. A. L. Miller, defends the actions as being completely legal and technically justified. He pointed out to *CE* that Asahi has considerable commercial experience in Japan, that the office's solicitors okayed the legal considerations of the contract, that an engineering board of review had judged the process technically sound, and that a top expert from OSW had observed Asahi's pilot plant in operation. Reporting from Japan, the OSW observer noted that plant exceeded design capacity on a feed composition similar to Webster's water, and was without scale after an extended test run.

Ionics, recently awarded $950,000 in contracts for electrically powered water desalting units for U. S. missile bases, brought a declaratory judgment against Asahi last July claiming that the Japanese firm was infringing on membrane patents held by Ionics. The decision is still pending in the Japanese patent office.

Research and development briefs

Accurate molecular weight determination of unknown materials in solution can be accomplished in a simple device developed by Stanford Research Institute, Menlo Park, Calif. Instrument contains a thermostatic chamber with two thermistor probes and atmosphere saturated with solvent vapor. When a drop of sample solution is applied to one probe and a drop of solvent to the other, temperature rise due to solvent condensation in the sample can be translated into the molecular weight of the unknown material.

Off-and-on magnetic properties in a new metallic compound have been discovered by Du Pont scientists. The material—chromium manganese antimonide—is unique because it becomes magnetic as temperature rises above a specific point. Below that temperature, the compound is nonmagnetic. Transition temperature can be varied from near absolute zero to about 200 F. by slightly varying the composition of the material.

For More Industry News . . . 78

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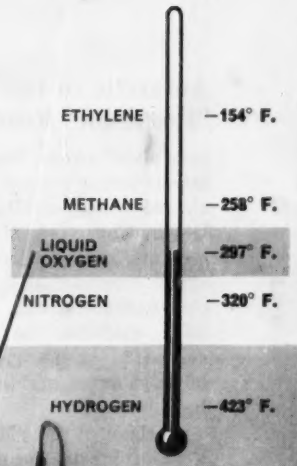
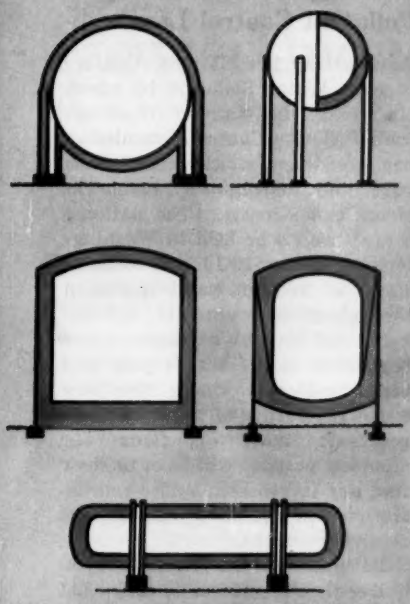


CRYOGENIC STORAGE VESSELS



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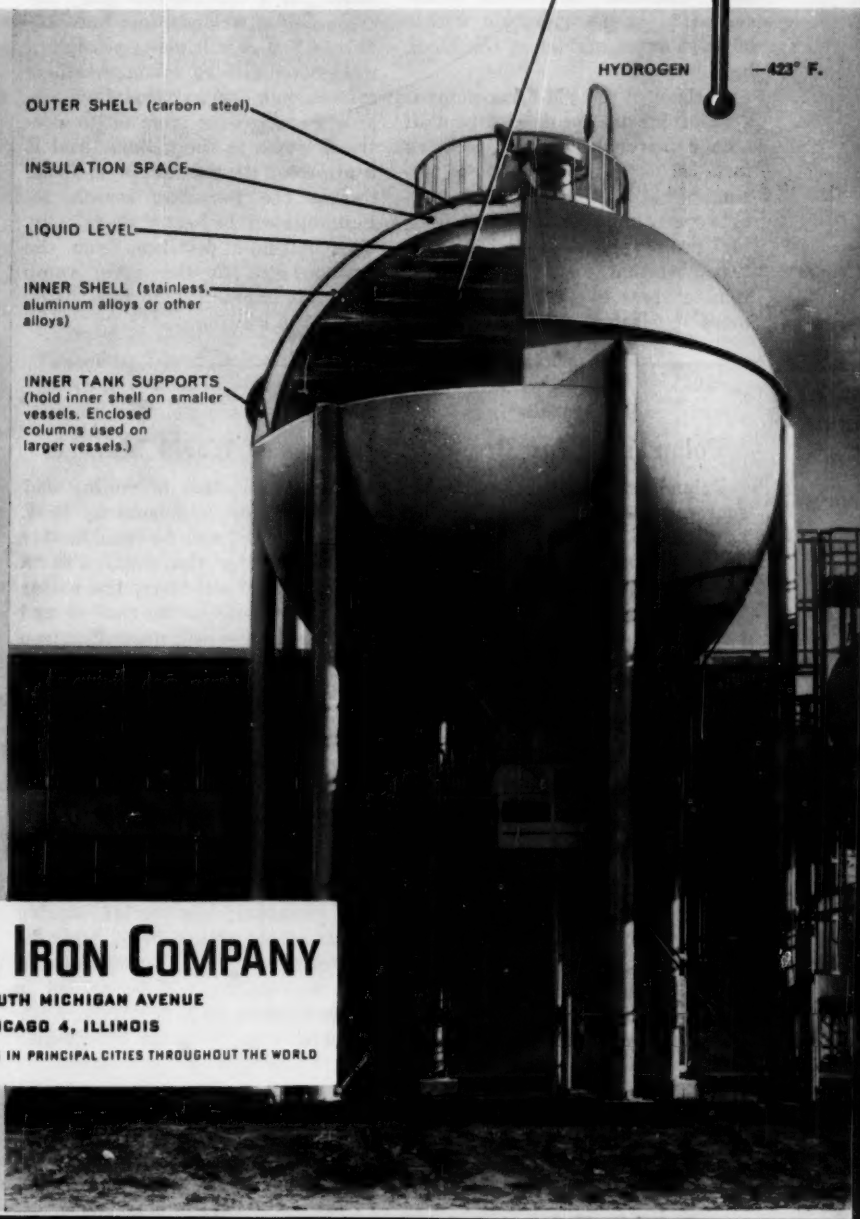
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Antarctic to Get First "Profitable" Reactor

In about a year, the first practical atomic power reactor will be loaded aboard a ship at Davisville, R. I. Destination: the U. S. scientific base at McMurdo Sound in the Antarctic. Prefabricated by the Martin Co., Baltimore, Md., in a series of 30-ft. modules, the reactor is designed to be in operation within 60 days after arrival at the U. S. base.

Christened the PM-3A, reactor is a milestone in the development of atomic power because it is being installed purely on the basis of economics, rather than merely to provide operating experience on a reactor prototype. Because of high transportation costs, diesel oil in remote areas like the Antarctic is more expensive than the nuclear fuel required to produce the same amount of electricity. It would take millions of gallons of oil to equal the power output of the PM-3A core.

The pressurized-water reactor, containing 730 3-ft.-long tubes filled with enriched uranium oxide pellets, will transfer heat to a secondary system that will produce steam for a turbine-generator. Increased electrical capacity at McMurdo Sound will make possible a more sophisticated communications system than now exists and will enable a changeover from oil to electrical stoves in the galleys. And if a projected second reactor is added during the following season, all buildings will be heated electrically. The half-mile distance from the reactor site to the main camp makes it impractical to pipe steam for use in heating.

Poland's Sulfur Program May Upset World Markets

Poland is drawing on the resources of all the Iron Curtain countries to establish a large sulfur producing project at the confluence of the San and Vistula rivers. Total sulfur reserves at that location are estimated at 95 million metric tons, making that country second only to Mexico's estimated 111 million metric tons of sulfur reserves.

Poland is now a sulfur importer but that will probably change by 1965 when it hopes to mine one million tons of sulfur ore. And rapid rises in output are planned for successive years, making it a primary supplier for other East European nations. Strong interest in the project by other Communist countries is shown by the fact that Czechoslovakia, East Germany and the Soviet Union will have invested several million dollars in mining and ore processing equipment by 1965.

The project will be considerably different from the usual Frasch sulfur operation. Here, the sulfur ores exist close to the surface and will be strip-mined, much like iron ores. A major problem has been the existence of H_2S in the water that runs through the area, constituting a hazard for the miners. Engineers, however, claim to have developed a purification scheme that will eliminate the H_2S.

The ore, containing 25-30% sulfur, will be ground and classified, then concentrated to 80-85% sulfur by flotation; recoveries during flotation are around 97%. After dewatering the slurry to 50% water, ore concentrate will be refined in autoclaves to 99.95% purity. Autoclaving step is based on Russian technology, although the pressure to be used (62 psig.) is higher than that previously employed by the Russians. In the autoclaves, sulfur separates from the slurry and settles to the bottom of the vessel, while the easily wetted tailings form a stable suspension with the water to provide a clean separation.

Washington Tightens Up Pollution Control Laws

Anticipating the National Conference on Water Pollution by about six weeks, the state of Washington's Pollution Control Commission has issued new, stricter regulations governing disposal of wastes in rivers and streams. (The national conference, to be held in Washington, D. C., Dec. 12-14, will consider ways to reduce water pollution throughout the country.)

Hardest hit by Washington's new regulation is the state's pulp and paper industry. Under the new order, the burden of proof has been reversed: now, applicants for dumping permits will have to show that any increase in sulfite concentration will not unduly pollute the receiving waters.

In addition, the regulation requires that the 11 sulfite mills that do not now have permanent permits from the state must have adequate waste recovery facilities in operation within three years.

Representatives of the pulp and paper industry have protested the new order, claiming that it will "entail cessation of operations" by several mills. A spokesman for Weyerhauser, while not worrying about closure, charges that it will have to spend $4-5 million for "unneeded recovery facilities."

Confronted by dwindling domestic supplies of fluorspar and an insatiable demand for hydrofluoric acid, cryolite and fluorine, five major industries are frantically searching for...

NEW SOURCES OF FLUORINE

Untapped low-grade fluorspar ores and phosphate rock may be the answer to the worldwide shortage of fluorine. It is not surprising, therefore, to note that nearly a dozen new processes for recovering usable fluorine compounds from these sources have mushroomed in recent years. And equipment redesign is improving the economics of fluorine recovery from the imported high-grade ores.

Domestic fluorspar, containing only between 35 and 75% CaF_2, takes up only 25% of U. S. demand, because deposits are often so unfavorably located that local transportation costs make the imported high-grade fluorspar (97-98% CaF_2) economically more attractive, even though this material gets here from as far as Italy and Spain.

However, several plants are now being built within reasonable reach of domestic deposits. For example, in California, Apache Chemical will start a new pilot plant next month for making anhydrous HF from 72% CaF_2 fluorspar rather than from the imported 97% acid-grade material. In Utah, United Heckathorne has a wet-process phosphoric acid plant and recovers the 1-3% fluorine content of phosphate rock to make cryolite. In Alabama, the Tennessee Valley Authority is developing a process for scavenging the 2-6% fluorine content of local phosphate rock.

All these efforts are intensified because of a grim possibility: if Red China, which is now heavily expanding her own steel and aluminum industries, curtails fluorspar exports to Russia and Japan, the world market will have to absorb a new demand for fluoride ores.

At home, in addition to such leading consumers as the aluminum industry and the Atomic Energy Commission, there is the prospect of a new growing outlet for HF in rocket fuels. Although present consumption in this field is still negligible, it won't stay so very long since the oxidizer, liquid fluorine, boosts the specific impulse (lb. thrust/lb. propellant/sec.) of any system by as much as 20%.

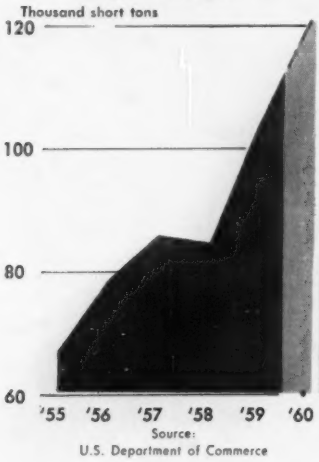
The aluminum industry takes the largest bite, 40%, of total HF production; this acid, usually reacted with aluminum hydroxide in the presence of caustic soda, yields cryolite. Chemically Na_3AlF_6, cryolite is the solvent for electrolytic baths of molten aluminum. With present supplies of fluorspar tight and because of few natural deposits of cryolite, aluminum producers—who go to the extent of recovering cryolite from old pot linings—are making synthetic cryolite by several new processes whose details are jealously guarded. For instance, Kaiser has recently found a way of synthesizing it from sodium silicofluoride, but the company remains silent on process details.

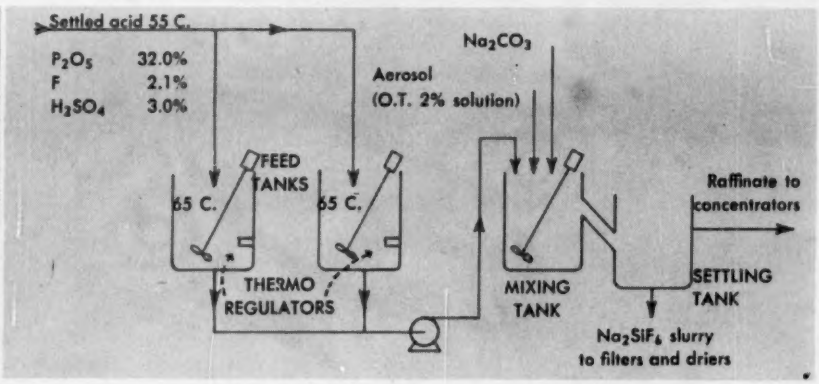
Almost at the same time, American Cyanamid has developed a new method for making sodium silicofluoride, disclosed details at the September meeting of the American Chemical Society, in New York.

► **Precipitation With Soda Ash**—Producing phosphoric acid by the conventional wet process, Cyanamid is also able to recover the 4% fluorine content of Florida pebble phosphate rock. This recovery takes place at the company's new pilot plant in Brewster, Fla.

Operated by Chemico, this pilot plant gives a valuable fluoride byproduct while simultaneously purifying the phosphoric acid. Here the byproduct (formed from silica and fluoride impurities) is hydrofluosilicic acid which, when precipitated with soda ash, yields sodium silico-

HF domestic production . . . . . and fluorine recovery come from sources like this:





Cyanamid's wet-process phosphoric acid plant recovers fluorine by precipitating sodium silicofluoride in H_3PO_4 solution (32% P_2O_5).

fluoride that is also used in vitreous enamels and opalescent glass, latex coagulants, insecticides, and in fluoridation of water.

Containing fluorine as calcium fluoride, the pebble phosphate rock reacts with sulfuric acid and gives phosphoric acid and gypsum. Also, calcium fluoride reacts with the mixed acids to form HF.

$$CaF_2 + 2H_3PO_4 \rightarrow Ca(H_2PO_4)_2 + 2HF$$

$$CaF_2 + H_2SO_4 \rightarrow CaSO_4 \cdot 2H_2O + 2HF$$

Because excess silica is present in the rock, the hydrofluoric acid produces hydrofluosilicic acid.

$$SiO_2 + 6HF \rightarrow H_2SiF_6 + 2H_2O$$

This solution, now containing mostly H_3PO_4, gypsum and H_2SiF_6, goes first through a settling tank to remove gypsum and then through acid feed tanks, where heating to 150 F. prevents any deposition of gypsum crystals during precipitation of sodium silicofluoride.

In the mixing tank, anhydrous sodium carbonate combines with the clear warm acid—a sodium to fluorine mole ratio of 1.25-1.50 gives greatest removal of fluorine from the acid. Adding a 2% solution of Aerosol O.T. effectively controls foaming.

The slurry flows into a settling tank where the sodium silicofluoride precipitates completely in 20 min.

$$H_2SiF_6 + Na_2CO_3 \rightarrow Na_2SiF_6 + CO_2 + H_2O$$

The 98% sodium silicofluoride cake is filtered, washed and dried, and the dilute phosphoric acid goes to the concentrators. Besides the obvious advantages of producing a valuable fluoride salt, this plant doesn't have the expenses involved in pollution control because hydrofluosilicic acid comes out of solution before the phosphoric acid is concentrated, thus minimizing the danger of HF leaks.

Also working with phosphate rock, Tennessee Valley Authority is perfecting a process for recovery of fluorine as ammonium fluoride. Some aluminum manufacturers react this ammonium fluoride with sodium aluminate to make cryolite. Essentially, the TVA process consists of water-scrubbing the gases from phosphate ore kilns to dissolve hydrofluoric acid. Recirculation of the scrubbing water, in wooden towers about 60 ft. high, lasts until F_2 content builds up to 25-30 gpl.

The solution is then treated with ammonia and—through careful pH control—silica and metal oxides precipitate out. Ammonium fluoride is then extracted from the clear liquor. Although the purification and precipitation step is still troublesome and expensive, this process is promising because it scavenges the 2-3% fluorine content of our abundant phosphate rock deposits.

▶ Better Mixing—In producing HF by acidulation of high-grade fluorspar with sulfuric acid, revised design has upped quality, cut cost.

Last spring, Vulcan-Cincinnati adopted the Ko-Kneader process, originally developed in Switzerland. Ko-Kneader has a new mechanical blender that handles 98% CaF_2 fluorspar with 96% sulfuric acid. Mixing is so efficient that only the stoichiometric quantities of acid and powdered fluorspar are required. The mixture is then pumped into an oil-fired kiln where the reaction occurs.

Briefly, here are the advantages: fluorspar converts completely to HF and gypsum without requiring excess sulfuric acid. The gypsum formed is not the corrosive slurry of conventional processes, but a marketable solid powder that dries in the kiln itself. The hydrofluoric acid produced is so clean that its subsequent condensation and purification to the anhydrous form become smooth, trouble-free steps.

While the cost of conventional plants range between $100-140/annual ton, depending on how elaborate are the HF purification systems installed, the much simpler Ko-Kneader may well go below the $100/ton limit.—EG

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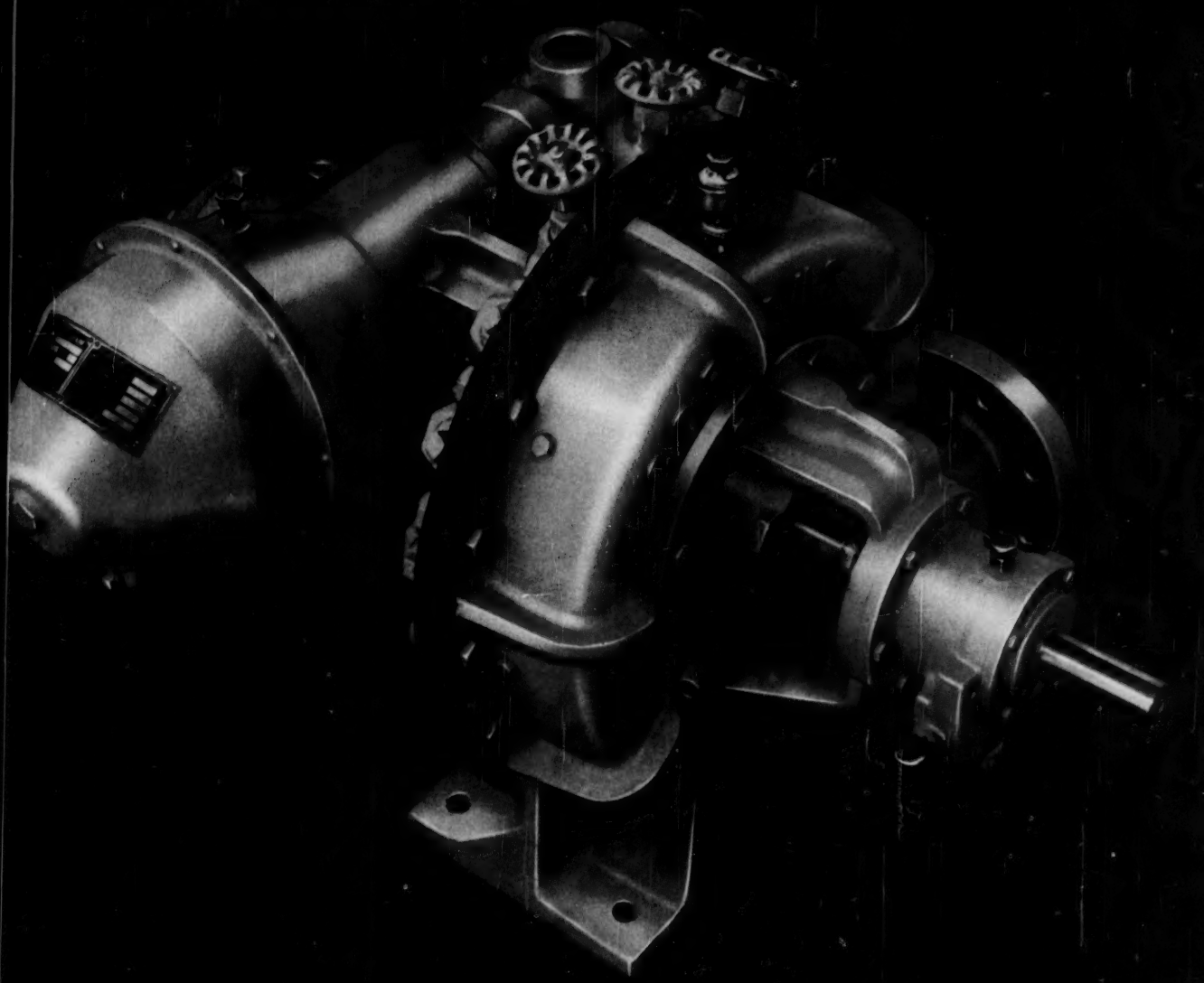

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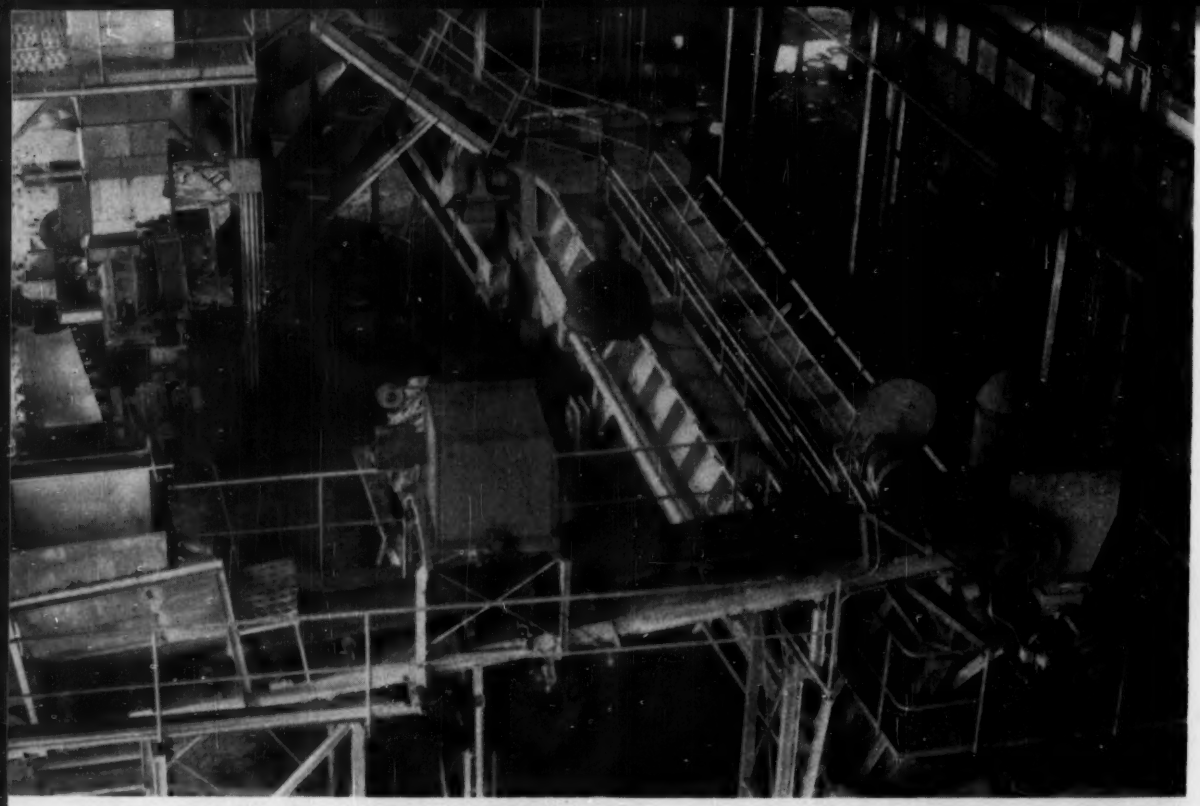

Heart of new process is continuous diffuser (right) which moves cane counter to flow of hot water.

SHAKEUP BREWING IN SUGAR PROCESSING

New diffusion technique that increases yield and cuts investment seen revolutionizing cane sugar industry.

Diffusion as a method for recovering juice from sugar cane now can claim some proved advantages reports John H. Payne of the Hawaiian Sugar Planters' Assn.

Speaking at a meeting of the Hawaii Sugar Technologists Assn. in Honolulu recently, Payne disclosed how a 15-16 ton/hr. pilot plant at the Kekaha Sugar Co., Kauai, performed in producing more than 23,000 tons of sugar during the 1959 and 1960 seasons.

Compared with conventional milling, the Kauai plant showed that diffusion:

- Improves recovery of sugar from cane approximately 4%—97.5% extraction compared with 93.6% average for Hawaiian mills.
- Produces a sirup with better refining characteristics.
- Decreases capital costs approximately $100/ton/day.
- Requires less electric power.
- Reduces plant maintenance.

▶How Process Operates—Key to the new technique is shredding the cane so that at least 94% of the sugar cells are ruptured. This permits the juice to be readily extracted with a minimum of water.

This is a departure from the Chemetron process (*Chem. Eng.*, July 1955, p. 124) which has been piloted at the Fellsmere (Fla.) Sugar Producers Assn. for more than five years.

In this process, cane is cut transversely into slices $\frac{1}{8}$-$\frac{1}{4}$ in. thick to permit extraction of the juice by osmosis and dialysis in a tall 3 ft. dia. diffuser.

Like the Hawaiian setup, this process reportedly increases extraction, and costs less to purchase, maintain and operate than a conventional mill train. It is to be used in a 400 ton/day mill being constructed in Trinidad.

▶Hawaiian Plant Details—In the pilot plant at Kekaha, cane is conveyed to a 15-in. prebreaker—a low-speed, high-torque machine similar to a meat grinder, but without an orifice plate. It chews the cane into pieces about 4-in. long.

Following weighing on a belt-type scale, the cane is discharged into an 18-in. vertical type swing-hammer mill which further comminutes it. Then the cane enters the diffuser.

The pilot diffuser was originally designed for studies of sugar beets. It consists of a sloping steam-jacketed trough 57 ft. long by 12-ft. wide. Trough is shaped to fit around two 54 in. dia. scrolls, each 45 ft. long. Flights of the scrolls are perforated.

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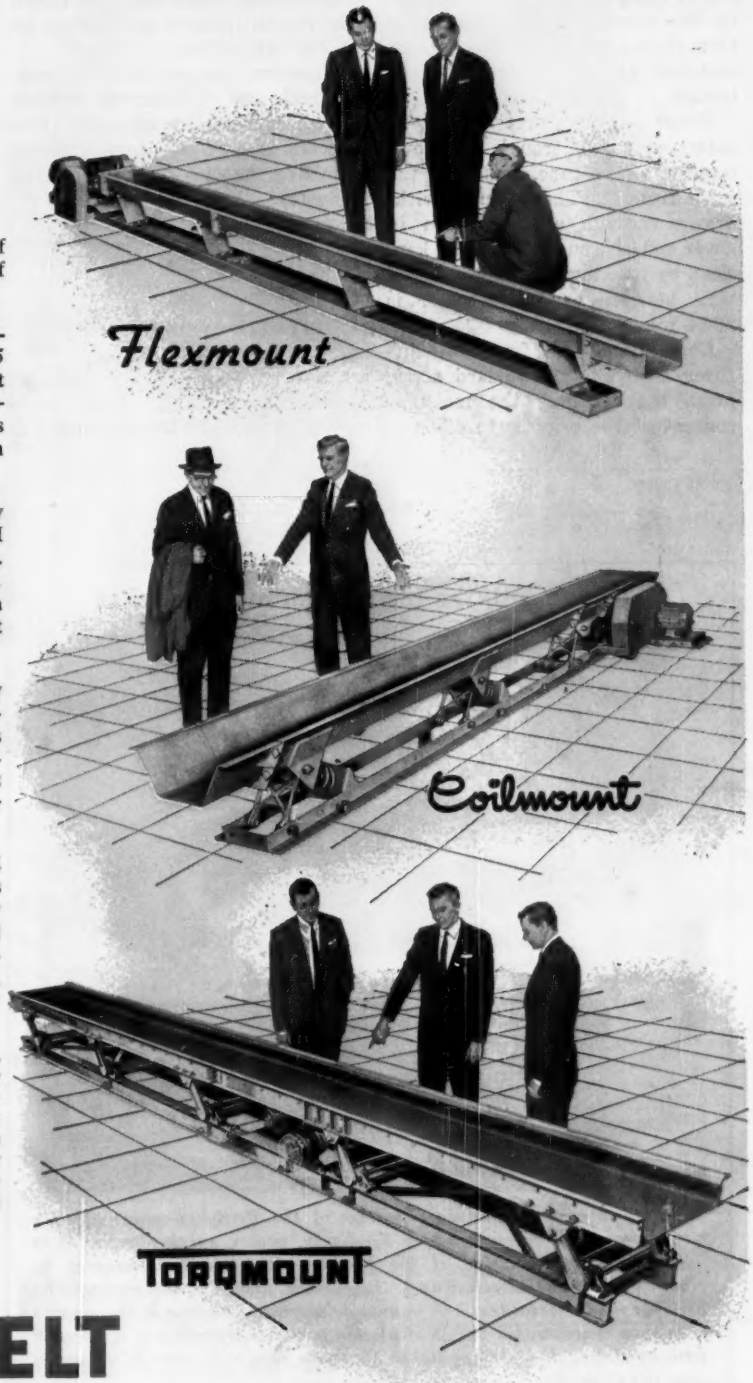

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scrolls, a breaker bar is attached to the inside of the diffuser trough. Scrolls rotate outwardly at the top at speeds of about 1 rpm.

Comminuted cane enters at lower end of trough and is moved upward by the scrolls, finally discharging from the top into two smaller scrolls installed at right angles to the trough.

Water at approximately 160 F. enters at top of trough and flows counter to the cane, removing the juice from it. The sirup is withdrawn through a fine screen in lower end of trough. Screen is kept clean by rotating scrapers. Contact time between cane and water is 36-50 min.

Cane discharged from the diffuser is fed to a standard screw press that reduces the moisture content of the bagasse to 45-50%. Juice pressed out here is added to that leaving the diffuser.

In spite of the previously mentioned advantages of the diffusion process, no immediate shift from conventional mills is anticipated. The reason: present mills have a lot of life left in them.

However, for expansion of present mills and replacement of worn heavy crushing machinery, this process is seen eventually revolutionizing the cane-sugar processing industry.—AVG

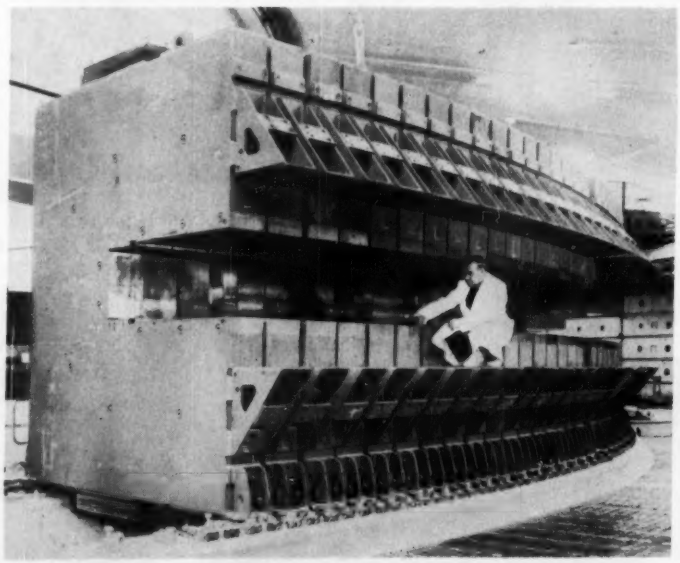
Current Developments In Thermoelectricity

Thermoelectricity, long used solely to indicate temperature differentials, broke into power-generating news again (*CE*, Oct. 3, 1960, p. 50) when two new thermoelectric devices were revealed. A working model of a propane-fueled generator has already been delivered to the Coast Guard, and a nuclear powered unit is under development for space exploration service.

The Coast Guard is testing one unit that it hopes will provide uninterrupted and unattended power for two years in navigation buoy and remote shore lights. Developed by Minnesota Mining and Mfg. Co., the 10-w., 12-v. generator will develop 200 w.-hr. for each pound of propane fuel, compared with the 10 w.-hr./lb. of batteries presently obtained from conventional lights.

General Electric is developing a nuclear power plant to provide from 5 to 30 kw. of electricity for satellites and manned space vehicles. About the size of a watermelon, the new unit will consist of a central core (reactor) made of a thick-walled graphite cylinder in whose walls will be encased channels holding pellets of nuclear fuel.

Looking into the teeth of an atom smasher



Scientist above is inspecting a section of the British Commonwealth's largest magnetic core, part of a 7,000-mev. proton synchroton, as it is maneuvered into position at the National Institute for Research in Nuclear Science (Harwell, Eng.). Synchroton, known as Nimrod, will be used for fundamental research in nuclear physics. Function of the magnet is to keep concentrated beams of atomic particles traveling in a circular path at almost the speed of light. Magnetic core will eventually form a ring 160 ft. in dia.

Explosions Kill Four, Injure 23

The recent string of explosions that have rocked the chemical industry (*Chem. Eng.*, Nov. 14, p. 114) are continuing:

An explosion and fire destroyed a synthetic resin plant in Wilmington, Del., on Nov. 8, killing four workers, injuring four others. The plant was a two-story structure belonging to the Synvar Corp. Cause of the blast is not known at the time this issue goes to press.

Earlier, an explosion in a distillation tower in Sun Oil's Marcus Hook, Pa., refinery injured 19 men. Explosion was followed by a fire that lasted about half an hour until extinguished by the company's own fire-fighting apparatus. Tower, used in production of automotive gasoline, was not in service at the time of the disaster; it had been taken off line for maintenance turnaround.

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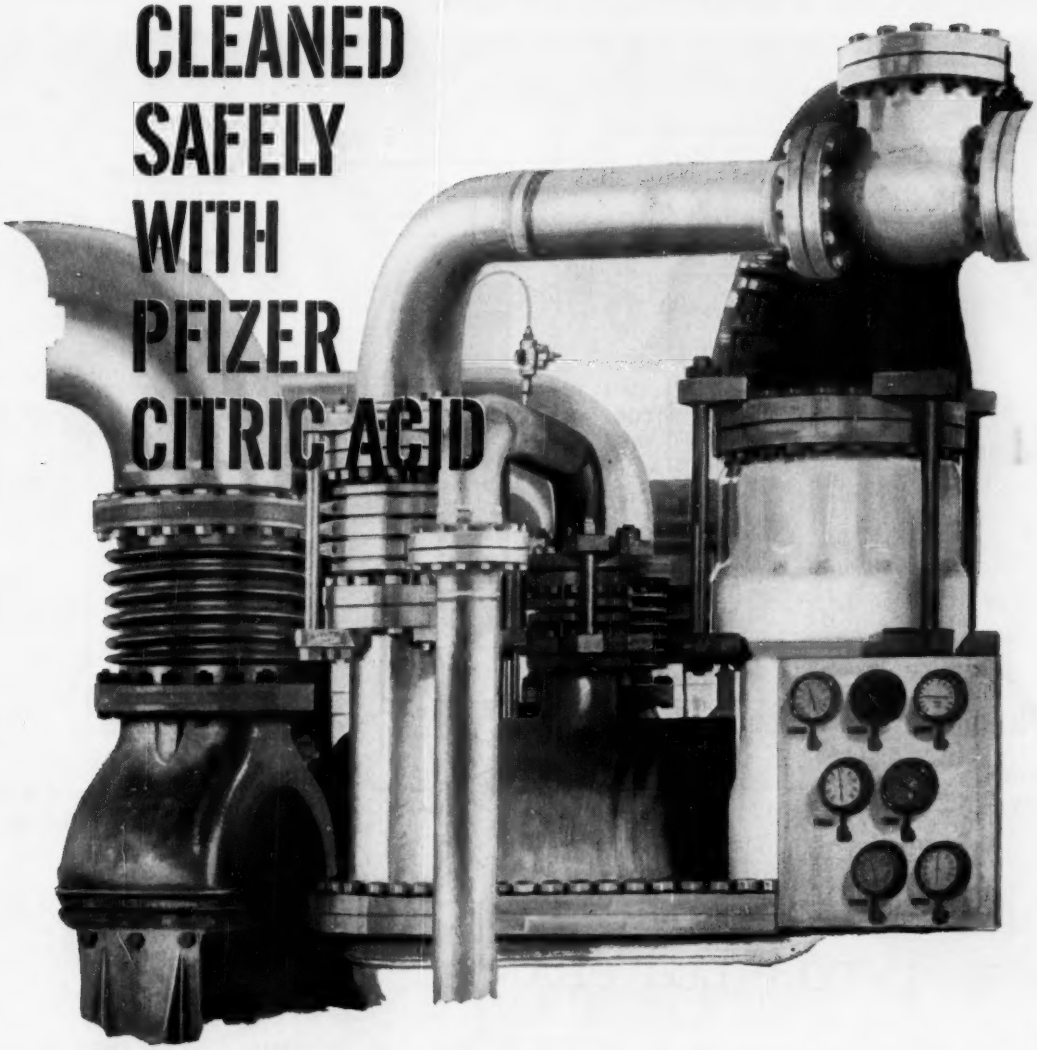

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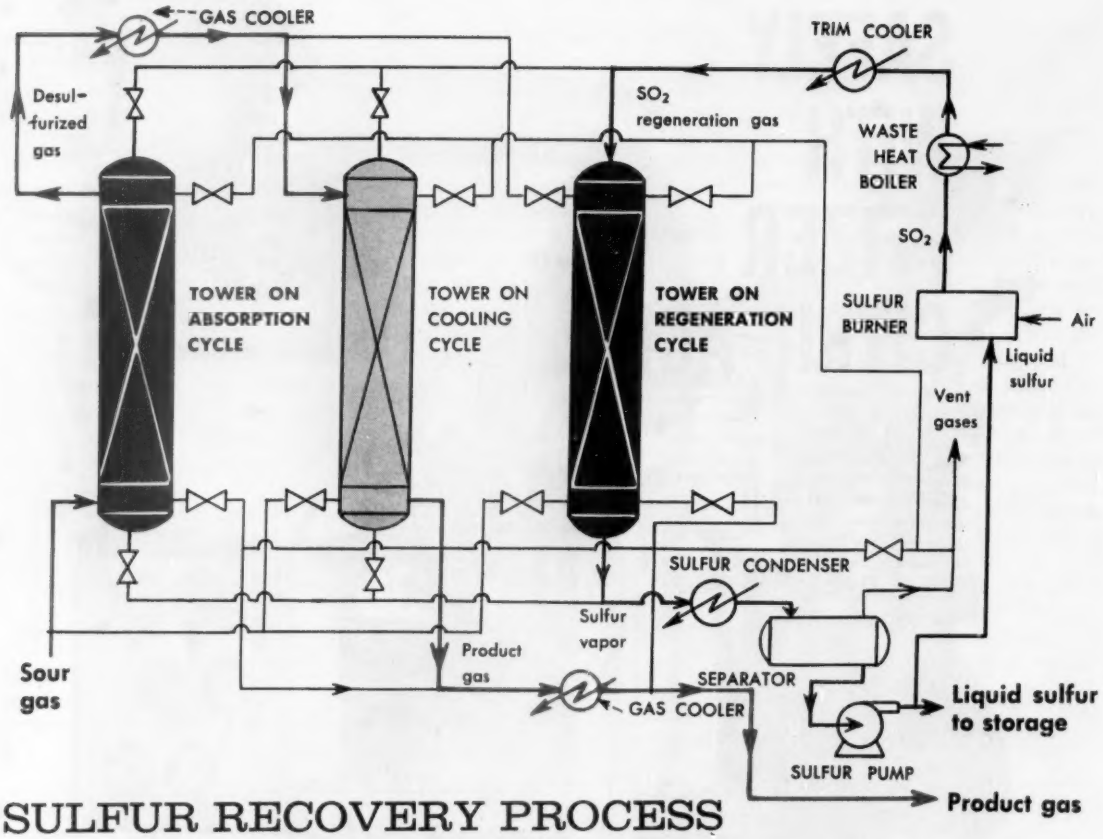

SULFUR RECOVERY PROCESS GOES INTO PILOT PLANT

Gas sweetening route uses novel regeneration step, supplies all process heat from recovered sulfur.

More details have been released on the sulfur recovery process developed by Krell & Associates, Houston, Tex., for sweetening natural gas (*Chementator*, Oct. 17, p. 83). Although the new route uses a relatively conventional H_2S adsorption cycle, it incorporates a totally new regeneration step that is expected to achieve savings in capital investment and operating costs.

Maloney-Crawford Tank & Service Co., Calgary, Alta., is now building a 100,000-cu.ft./day pilot unit in Calgary to treat sour natural gas containing 15% H_2S. A second pilot unit is also being built in the U. S., in cooperation with an unidentified engineering firm, will use a slightly different flowsheet from the one shown above.

The Haines process (named after inventor Harry Haines of Krell & Associates) is the latest in a series of sweetening processes that have appeared in the past year. Two new routes were described only a few weeks ago (*Chementator*, Nov. 14, p. 103). One reason for this interest in H_2S removal is the increasing amount of sour gas that has to be handled in natural gas producing operations. In Alberta, where the Haines process will be piloted, one expert estimates that within the next four to five years, about 5,000-6,000 long tons of sulfur will be recovered from the area's fields each day.

▶ **Adsorption Cycle**—As shown in the above flowsheet, the unit is an adsorption plant that operates on relatively short cycles (45-180 min.). Unlike hydrocarbon adsorption units, however, the time cycle is determined by the sour gas concentration rather than by linear gas velocities.

Sour gas enters the bottom of the first tower and flows upward through synthetic zeolite (calcium aluminosilicate) pellets that adsorb the H_2S. Sensible heat, generated by the adsorption reaction, is removed in a heat exchanger. Cooled gas then flows downward through a second column to cool the freshly regenerated adsorbent. Series flow also provides a built-in safety factor: if a process upset occurs, the tower on the cooling cycle acts as a

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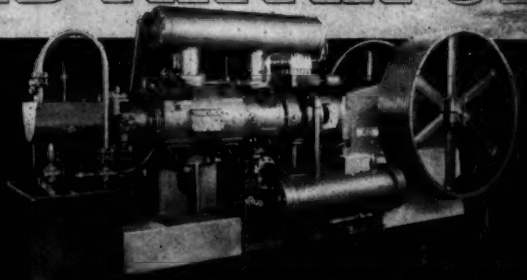

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second adsorption unit to trap any remaining H_2S in the product gas stream.

▶ **Regeneration Cycle**—To remove adsorbed H_2S from the zeolite, an SO_2 stream at about 600 F. flows downward through the loaded adsorbent, which also acts as a Claus catalyst, producing elemental sulfur and water. Since the cold adsorbent functions as a heat sink, temperature rise across the tower is lower than the rise obtained with conventional Claus catalyst chambers under steady state conditions.

Sulfur vapors from the regeneration tower are condensed and one-third of the liquid sulfur is pumped to a sulfur burner where it is burned to SO_2 to provide the regeneration gas. High - pressure steam can be recovered from the hot SO_2 stream by using a waste-heat boiler, which has an exit temperature closely approximating the exit temperature of the regeneration tower (600 F.). Unless lower pressure steam is desired, temperature drop across the trim cooler is essentially equal to the temperature rise across the regeneration tower.

▶ **Totaling Up the Savings**—The process is a net steam producer, since all of the heat needed by the process is generated from the sulfur portion of the sour gas. Some other sweetening processes burn a portion of the product gas for fuel. With the long-term trend towards lower sulfur prices and higher natural gas prices, the differential in fuel costs should give the Haines process an economic advantage. The only utility required is cooling water.

Cost of a commercial plant to treat 8 million cu. ft./day of sour natural gas (15% H_2S) is estimated at $600,000, exclusive of offsite facilities. Excess steam can be used to drive a refrigerated cooling system to reduce the hydrocarbon dewpoint of the product gas. This should be an added advantage in Canadian operations where gas transmission companies require a 15 F. hydrocarbon dewpoint at 800 psia.—RAL

Plasma spray coats steel with invulnerable armor

Engineers at Rocketdyne's McGregor, Tex., facility have found a way to make inexpensive ($95) rocket nozzles that can be re-used many times for static rocket firings. (Exhaust gases from rocket motors are so erosive that ordinary nozzles are ruined after one shot.) Using a plasma-spray machine built by Plasmadyne Corp., engineers now coat mild-steel nozzles with a thin (0.00125-in.) film of alumina. After a firing, nozzle is recoated with alumina, is ready to go again.

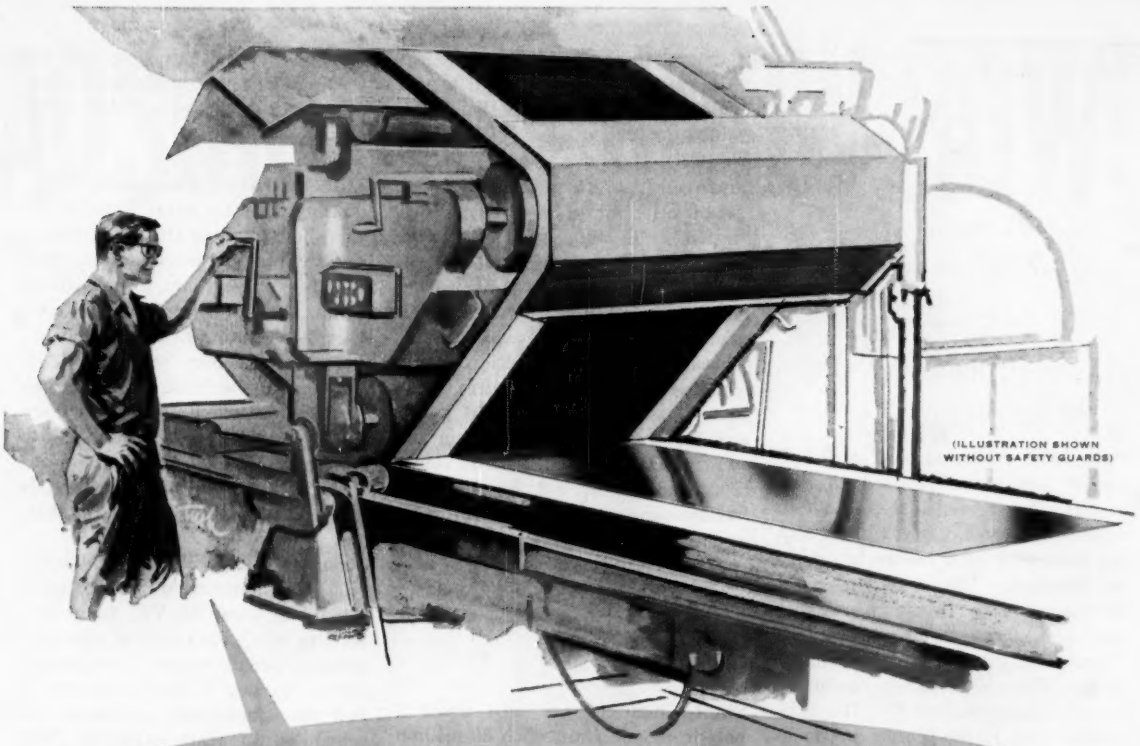
Invisible "Balloons" Cut Evaporation Loss

A hollow plastic sphere—so small that you can't see it—can save thousands of dollars in evaporation losses from tanks containing crude oil and other oil products. Together with millions of its kind, the sphere is used to form a film or foam layer over the surface of the stored liquid, reducing product evaporation up to 80%.

Developed by Standard Oil Co. of Ohio, the spheres, called Microballoons, are floated on the surface in layers from ¼ to 1-in. thick. The particles used for this service have to be small enough to pack together (thus minimizing capillary spaces between spheres) and light enough to float. Spaces between Microballoons become choked with higher boiling components, seal off the liquid from the atmosphere. Dollar savings to Sohio from use of Microballoon foam layers have been significant. In one installation involving 82 tanks, savings the first year were greater than the cost of applying Microballoons. Sohio estimates that total savings are close to a quarter of a million dollars/yr. for all installations.

Sohio realized its problem in the mid-1950's when it discovered that evaporation losses from 100 60-yr.-old tanks were exceeding 50,000 bbl./yr. Dollar loss was severe but not sufficient to justify replacement of 2 million bbl. of tankage.

Researchers tried chemical foams, sawdust, expanded plastic blocks—even ping pong balls—before they developed Microballoons.



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Processes

Pulp from cotton stalks, long discussed but never realized in this country, has moved a step closer to reality in Kern County, Calif., with the launching of a research project to determine the economic practicability of a cotton processing operation. Organized by a group of Kern County growers, program includes process research conducted by Houston Fearless Co. It's estimated that Kern County produces over 400,000 tons/yr. of cotton stalks that are currently being plowed back into the soil.

Carbamate recycle urea process, first announced two years ago (*Chem. Eng.*, Jan 26, 1959, p. 48), is now operating at a Cooperative Farm Chemicals plant in Lawrence, Kan. Developed by Chemical Construction Corp., New York, process utilizes liquid recycle of unreacted ammonia and CO_2 to achieve savings in equipment. Process is also said to produce a high urea concentration before the evaporation stage and to require less steam, electricity and cooling water than other processes.

Simplified chromium plating processes for aluminum and other metals have been developed by General Development Corp., Miami, Fla. Diamond Alkali will handle marketing and commercialization of the new methods, called the Duramir processes. One technique plates chromium directly on aluminum and aluminum alloys. Another provides a brighter, more durable chromium coating on a variety of base metals that have received an initial nickel plate. Third process, adaptable to the other new systems, produces a corrosion-resistant, crack-free bright chromium plate on aluminum as well as other base metals.

Improved blast furnace output via fuel oil injection (*Chem. Eng.*, Nov. 14, p. 108) is being tried by one of France's leading producers of special steels, Societe des Acieries de Pompey. Fuel oil injection will raise pig iron output 10-20% while decreasing coke consumption. Pompey has been experimenting with fuel oil addition for several years and has received a patent on its own injection device. In this country, Esso Research & Engineering has announced that it is working on a similar system.

Plants

Shell Chemical Co. will build a polypropylene plant with 80 million lb./yr. initial capacity at West Deptford Township, near Woodbury, N. J. It will make the polymer by an undisclosed new process developed by the firm through a 4-year, multimillion-dollar research program. A research and technical service center will also be erected at the plant site, to provide technical assistance for users of the product.

Columbia-Southern Chemical Corp. will construct a multimillion-dollar plant to produce chrome chemicals at Corpus Christi, Tex. It will complement the firm's existing facilities for making products in this category at Jersey City, N. J. Engineering design for the plant will be by W. P. Kidde (Southwest) Co., Houston. Chrome chemicals, manufactured from chromate ore mined in South Africa, are used mainly in leather tanning, chromium plating, paints, wood preservatives and corrosion inhibitors.

United Pacific Aluminum Corp., Los Angeles, will build a potline aluminum reduction and processing plant at Longview, Wash., and has signed a 20-year contract to receive 90,000 kw. of power for the facility from the Bonneville Power Administration. Annual capacity will be 45,000 tons of pig aluminum. Initial power deliveries are scheduled for January 31, 1963.

Solar Nitrogen Chemicals, Inc., equally owned by Atlas Powder Co. and The Standard Oil Co. (Ohio), has awarded a construction contract for a urea plant to be built at Joplin, Mo. Recipient of the contract is Arthur G. McKee & Co., Cleveland. Facility will cost $2,-3 million, will be built under license from Stamicarbon, N.V., a wholly owned subsidiary of Dutch State Mines, of The Netherlands. Construction is to start in February, is to be completed by next October.

Corning Glass Works, Corning, N. Y., has announced plans to build a plant at Danville, Va., for manufacture of a wide range of specialty glasses. Construction at an 89-acre site is to begin about January 1, and manufacturing operations are scheduled to start early in 1962. Products will include a 96%-silica glass used for laboratory and industrial equipment, several glass grades for use in the electronics industry, and a number of grades to be produced in tube or sheet forms for technical applications. Plant will have 190,000 sq. ft. floor space, will initially employ about 200 persons.

Allied Chemical Corp.'s Solvay Process Div. will expand its chlorine-caustic soda production capacity at Moundsville, W. Va., by about 20,000 tons/yr. Company requires the additional capacity to meet captive requirements for chlorine for making vinyl chloride and chlorinated methanes. Also, Solvay expects an increase in chlorine demand by the textile, pulp and paper industries served by the Moundsville plant. Facilities to provide the additional capacity are scheduled for completion in 1961.

Northern Natural Gas Co.'s subsidiary, Northern Gas Products Co., plans to build a propane extraction plant at Bushton, Kan. It will be able to process 900 million cu. ft. of gas per day, is expected to cost

(CPI Briefs continued on page 197)

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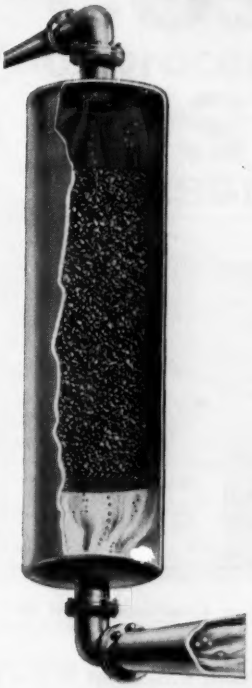

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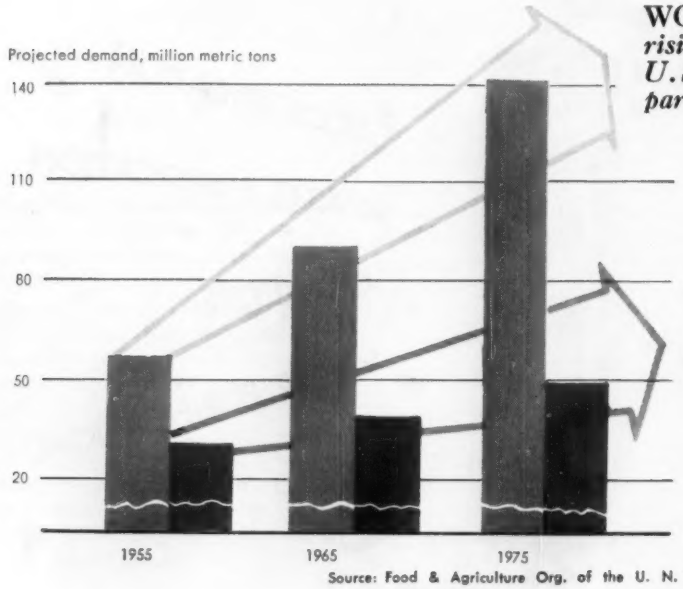
FOR PULP & PAPER: NEW PROBLEMS



Source: Food & Agriculture Org. of the U. N.

WORLD ***demand for paper is rising rapidly. Question facing U. S. firms is how much they will participate in these new markets.***

UNITED STATES ***consumption is rising more slowly. Main problem at home is finding ways to counter the profit squeeze.***

R. A. LABINE
Assistant Editor

"The pulp and paper industry is a pretty good barometer of business activity," says the president of a large paper company. "I can tell from our orders whether the price of eggs is going up or down."

Being a fairly accurate—though not infallible—bellwether of the domestic economy, pulp and paper has reflected the experience of many other industries this year: 1960, though not a bad year, has failed to live up to its advance billing. After early predictions of a record 36 million tons of paper and board production, this year's output will barely top last year's 34.0 million tons. Best-informed estimate of production in 1960: 34.4 million tons.

Upsetting an otherwise comfortable situation is the additional capacity now coming on stream, prompted by the tight market conditions of a few years ago. The industry has been operating at around 93-94% of capacity compared with about 98% a year ago. Growing capacity in the face of static markets has led to price cutting in some areas. "Our biggest worries," declares an official of a major paper producer, "are rising production costs and the fact that the price of paper is not going up. It's as simple as that." Paper companies, like many chemical companies, are victims of the common ailment which is known as the profit squeeze.

▶**Some Bright Spots**—Cheering news for U. S. pulp and paper producers is contained in a comprehensive world paper consumption report issued by the Food & Agriculture Organization of the United Nations.

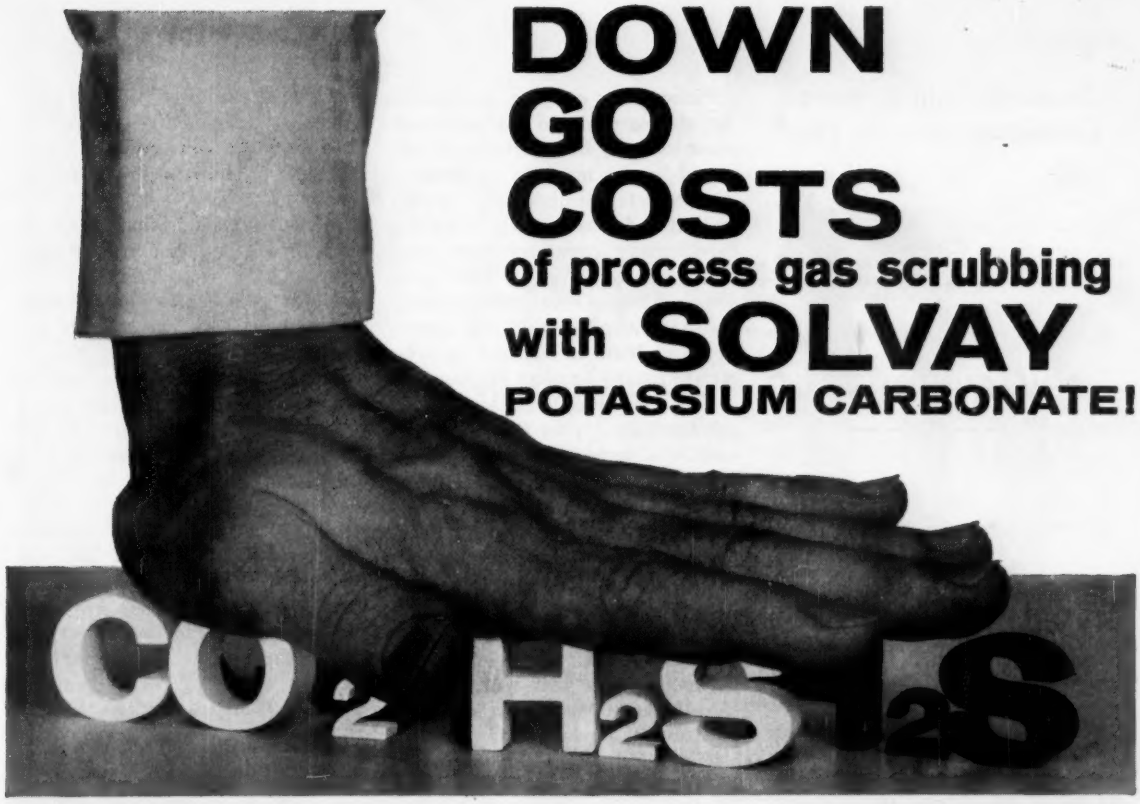
This report shows that while world paper and board demand in 1955 was only 56 million metric tons, consumption by 1975 will be about 141 million metric tons. Although the U. S. will still be the biggest paper and board consumer in 1975 (estimate: 54 million metric tons), there will be a widening gap between U. S. demand and the quantities that will be required by a burgeoning world population.

▶**Big Potential**—A major question facing U. S. pulp and paper manufacturers is how widely domestic firms will share in this explosive growth.

Some companies are already investing in converting plants abroad. Foreign investment, which stood at only $378 million in 1950, had climbed to $811 million by 1958. The pulp and paper industry, however, has been less eager to invest overseas than has the chemical industry.

Another question to be decided is how much of the world markets can be supplied from U. S. plants. U. S. paper exports now average only 3%—about 1 million tons—of total annual production. (And this is more than counterbalanced by imports of 5.5 million tons/yr. pulp from Canada.) Much of our exports are distressed-sale types, rather than regular supplying of carefully cultivated markets.

▶**What About Exports?**—Some industry observers doubt that the



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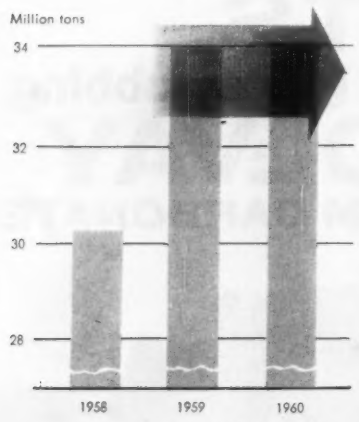
Domestic pulp & paper production: level in 1960



Source: American Pulp & Paper Assn.

U. S. has enough resources to become a big pulp and paper exporter. Although our timber reserves are in good shape—forests are being replaced faster than they are being cut—many believe that our expanding population at home will prevent the U. S. from becoming a big pulp exporter. For the short run, however, expanding foreign markets are providing a convenient outlet for some excess U. S. production.

For the long run, most observers believe the best prospect for U. S. participation in world markets is through investment in foreign mills. Building plants overseas also gets around many trade and tariff problems that currently plague U. S. exports.

Other companies prefer just to license processes or to work through joint ventures with foreign firms. Crown Zellerbach, for example, has licensed its new pulp-from-bagasse process to Sahu Jain, Ltd., Calcutta, India, for use in a new mill being built near Bombay.

▶ **Activity Overseas**—According to the latest quarterly report of the U. S. Dept. of Commerce, overseas plans for new pulp and paper plants, or additions to existing facilities, indicate widespread anticipation of rapidly growing worldwide demand.

Finland, for example, is expanding all segments of its pulp and paper industry in expectation of enlarged foreign markets. In Sweden, too, projects are under way to step up output for export. On the other hand, many countries want new mills mainly to meet their own domestic needs. Guatemala recently put its first paper mill into operation and India is engaged in projects to utilize bagasse for pulp.

U. S. companies increased exports substantially during 1960 compared with the same 1959 period. Outstanding gain was in wood pulp, up from 363,000 tons to nearly 737,000 tons during the first eight months. More modest increases were registered by paper and board, up from 356,000 tons to 417,000 tons over the first half of 1960.

▶ **Problems at Home**—Although production this year will equal or slightly exceed last year's output, profits will be less than in 1959. Higher production costs, including increased labor rates and cost of machinery, and keen competition for markets that prevents compensating price increases, have all combined to put the squeeze on profits.

Part of the trouble can be attributed to increasing acceptance of aluminum and plastics in the packaging field. Midsummer price reductions on thin polyethylene film—about 5%—are having an effect on producers of papers for garment, food and other wrappers. Most industry people believe, however, that whatever inroads new materials are making will be offset by new markets for paper elsewhere.

Major gain chalked up by paper makers this year has been in machine-coated papers, which climbed about 19%, reflecting increased activity in printing and publishing.

▶ **Loosening the Squeeze**—In efforts to fatten up currently slim profit margins, many pulp and paper companies are pouring increasing amounts into research and development. A recent McGraw-Hill survey shows that planned research outlays for 1963 are $95.9 million, a 50% increase over the 1959 figure. Although the industry has traditionally invested a smaller percentage of its profits in research than has the chemical industry, the gap is narrowing.

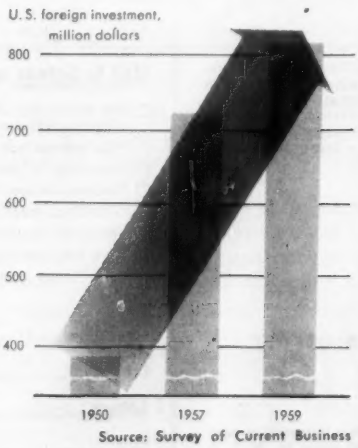
Reducing production costs through increasing use of automatic control is receiving widespread attention. As a measure of the importance that engineers and technical management attach to this area, the Instrument Society of America in the last two years has sponsored symposia, devoted exclusively to pulp and paper control technology, that have drawn hundreds of attendees.

▶ **Changing Technology**—Another attempt at lowering production costs has been the introduction of continuous digestion, of which the Kamyr system is probably the most successful (*Chem. Eng.*, Sept. 21, 1959, pp. 136-139).

Some critics contend that the initial cost of continuous digesters offsets the operational savings and that the cost of downtime is too high. But most informed sources believe that for a 200-ton/day-or-larger mill built from scratch, continuous digesters have a real economic edge over batch systems.

Firms are also looking for ways to boost pulp yields from the usual 43-47% range up to 50-60% and even 80-90% where end uses will accept the lower-quality pulp that results. Multistage sulfite cooking

Paper industry investment abroad: climbing rapidly



Source: Survey of Current Business

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Tensile Strength, PSI	31,000 Min.	60,000 Min.	70,000 Min.
Yield Strength, PSI		45,000* Min.	36,000 Min.
Elongation, % in 2" Gage Length	NIL	15	22
Modulus of Elasticity, PSI	12—20x10⁶	24x10⁶	30x10⁶

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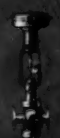

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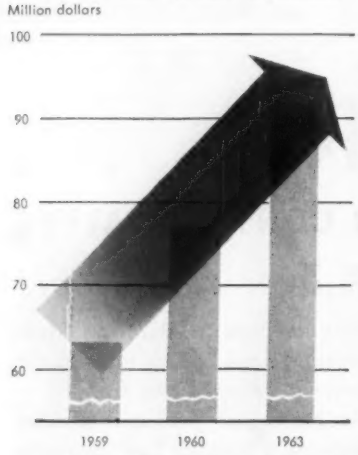
R & D outlays: increasing to fight the profit squeeze



Source: McGraw-Hill Dept. of Economics

processes such as those developed by Sivola (Finland) and Stora Kopparberg (Sweden) show great promise for pulping low-grade pine woods at high yields with good product quality.

▶**Shifting Raw Materials**—Although our timber resources are adequate, there is a growing scarcity of easy-to-pulp softwoods. During the first half of 1960, hardwood comprised 20.9% of all woods used, compared with 19.6% in 1959. In the North Central states, there are more hardwoods used than softwoods, the ratio being about 1.16 to 1. An extreme example is the Scott Paper's mill at Anacortes, Wash., which operates entirely on alder, a fast-growing hardwood that was once considered a weed tree.

The trend to hardwood has increased the popularity of the cold-soda process, which enables pulpers to use hardwoods for newsprint. The kraft and magnesium-base sulfite processes are also gaining because they allow almost complete chemical recovery—a distinct advantage at a time when state and federal authorities are taking an increasingly dim view of dumping pulping liquors in rivers and streams.

Use of scrap wood chips from sawmill operations has also become an important trend, especially on the West Coast where large timber operations are centered. Cascade Kraft Corp.'s 150-ton/day pulp and paper mill at Wallula, Wash., for example, operates completely on sawmill chips.

▶**What About Silvichemicals?**—More pulp and paper companies are looking at wood-derived chemicals as a way to larger profits, faster payouts and product diversification. Since a pulp mill wastes about 65% of its raw material, there is enough wood waste to supply an industry several times the size of the petrochemical industry—if economical processes and markets can be developed.

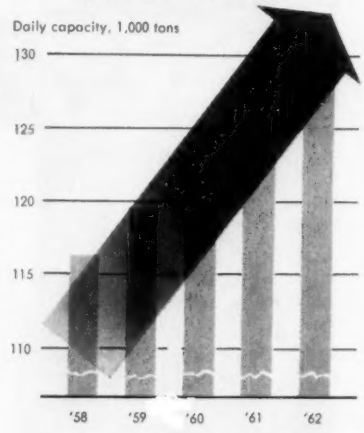
W. M. Hearon, vice president of Crown Zellerbach, summed up the status of the silvichemical business in a recent talk before the Western Chemical Market Research Group, in San Francisco. Right now, sales of conventional pulping byproducts represent just a small fraction of the total silvichemical potential. Crude tall oil, the biggest single product, is produced at a rate of 450,000 tons/yr., accounts for $25 million sales. Around 30 million gal./yr. of turpentine is collected in paper mills, yielding about $10 million in revenue.

Pulping waste liquors are a large potential source of chemicals. Sulfite liquor products are already being sold for dust binders for roadways and as dispersing agents for gypsum and concrete to reduce amount of water required. Another large market is in additives for oil well drilling muds. Total income derived from sulfite liquor products is about $100 million.

▶**New Chemical Paths**—Crown Zellerbach, which produces conventional silvichemicals such as turpentine and tall oil, has developed a process to make dimethyl sulfide from the lignin in kraft liquor. This in turn can be converted to dimethyl sulfoxide, a versatile solvent. C-Z is bringing on stream a new unit at its Bogalusa, La., mill that will turn out 10 million lb./yr. DMSO and 1 million lb./yr. methyl mercaptan.

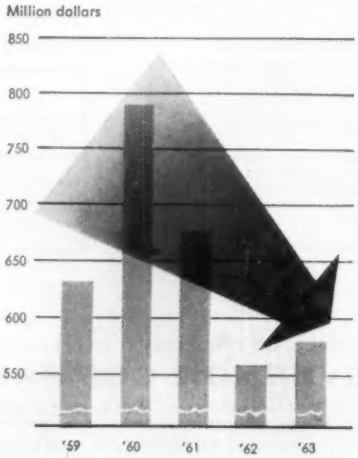
Georgia-Pacific Corp. has started an experimental program to produce cyanide chemicals from pulping byproducts. G-P plans to turn out 200,000-300,000 lb./mo. of sodium, ferric and other cyanides from a pilot plant on the lower Columbia River in Washington state. Aim is to develop a broad line of products rather than concentrating on any specific chemical.

U. S. paper & board capacity: gradual buildup



Source: American Pulp & Paper Assn.

Capital spending plans: tapering off



Source: McGraw-Hill Dept. of Economics

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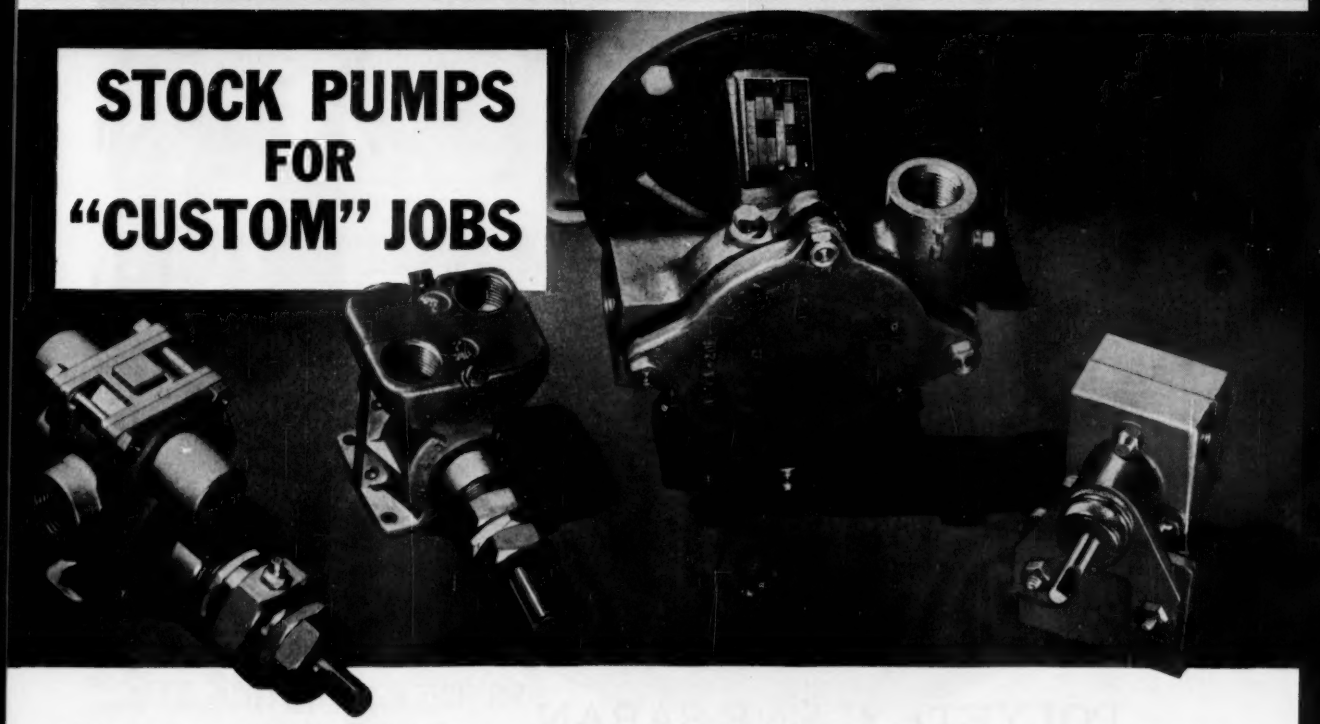

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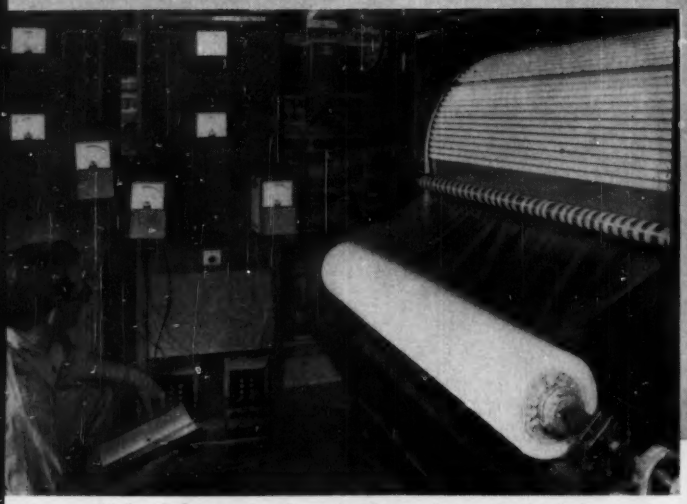

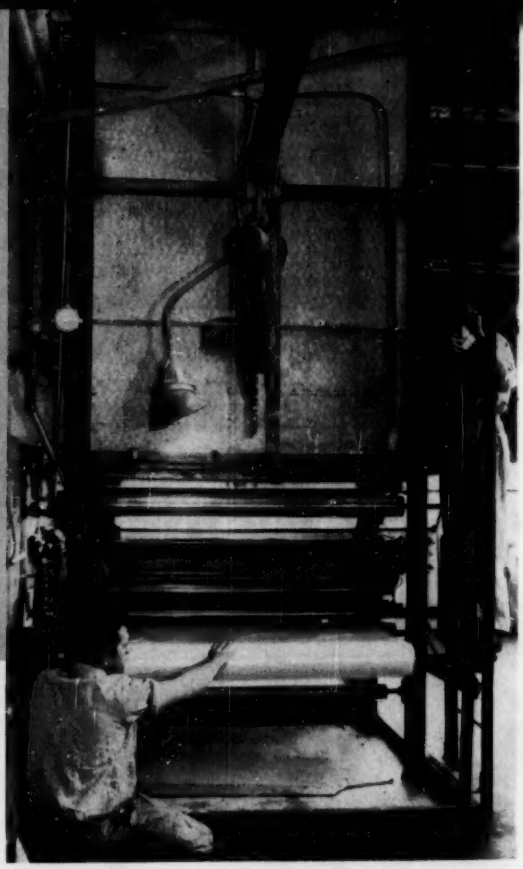

Polyethylene goes through electronic treatment before being coated with saran. Process alters the film's surface and makes possible the bonding of a saran coating.

After electronic treatment, the polyethylene film is knife-coated with saran, then wound through this 30-ft, high drying oven.

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Polyethylene-saran films are the result of several years of research. Development work has been slow because polyethylene and saran are difficult to bond. But Plastoid Corp. now has a process that, unlike treatments attempted previously, avoids the production of ozone when the polyethylene film undergoes the electronic treatment necessary to make the film's surface receptive to saran.

Of the many polyethylenes tried, U.S.I.'s Petrothene 200 resin has given the best results because it produces a tough film that has surface uniformity and can change radically under electronic treatment. None of the characteristic properties of the two component films are lost in the bonding step, which now occurs without adhesives.—**U. S. Industrial Chemicals Co., New York.** **98A**

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Setanon 600 is an aromatic ketone resin principally based on cyclohexanone but with its melting point at a considerably higher level than cyclohexanone resins. Together with a softening point of 105-110 C. (ring and ball method) Setanon has lighter color and considerably better color fastness than other products of comparable hardness. Even at ultraviolet radiation, only minimum yellowing will occur.

Because of its excellent adhesion and good compatibility with all types of pigments found in inks, this resin will go into the fabrication of flexographic and rotogravure printing inks.

Its resistance to rapid drying and blocking on the press allows handling of Setanon's printed

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stock without offsetting or smudging. The adherence of printing inks to such reluctant surfaces as cellophane and polyethylene is also greatly improved.

In high-quality nitrocellulose lacquers, Setanon 600 gives much lighter color and better retention than maleic resins, and at the same time provides good polishing properties because of its high softening point. Unlike most cyclohexanone resins, Setanon, is soluble in alcohols, glycols, acetates, esters and ketones.—**Kunstharsfabriek Synthese N.V., Katwijk, Holland.** 98B

Rayon

New type simplifies manufacture of paper and wet-laid nonwovens.

Multicell rayon RD-101, is a short fiber that makes possible the manufacture of a paperlike material from 100% man-made fibers without adding pulps, fillers or bonding agents other than water to form a slurry.

When formed into a wet-laid web and dried, these multicellular cellulosic fibers firmly bond themselves and lock into place other fibers that they contact. This enables them to produce wet-formed nonwoven fabrics and papers composed of 100% RD-101 fibers or a blend with other fibers or pulp.

When supplied as a 1.5 denier ¼-in. high-bonding type, RD-101 wets out readily and disperses freely without flocculating and with little evidence of stringing or lumping in dilute paper slurry where the uniformly cut fibers are given a minimum of stirring.

Also made experimentally in a wide range of deniers and lengths with low as well as high bonding strengths, RD-101 low-bonding types are said to produce soft, opaque sheets with good cohesion for processing the wet web across the paper machine. The heavier deniers make less-dense sheets of lower strength per unit weight.

This rayon fiber enters in the manufacture of several products ranging from backing for vinyl coatings to carbon and mimeograph papers, filters, interliners and yarns. — **American Viscose Corp., Marcus Hook, Pa.** 100A

Zeolite crystals

Product acts as catalyst carrier, separates hydrocarbons and dehydrates gases.

Zeolite crystals credited with great capacity for selective adsorption and dehydration have been trademarked Microtraps. The structure of these alumino-silicates is characterized by a repeating three-dimensional network of large, open cages interconnected by smaller uniform pores.

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Microtraps also differentiate between molecules on the basis of polarity or degree of saturation, by adsorbing preferentially the most highly polar or unsaturated molecules. The tenacity with which they retain certain compounds under moderate temperatures and the ease with which they can be regenerated at elevated temperatures make them ideal catalyst carriers.

They are stable at temperatures as high as 1,000 F., inert in a wide range of organic compounds and are not harmed by water. Because of their slightly basic nature, they are subject to attack by strong acids.—**Davison Chemical Div., W. R. Grace & Co., Baltimore.** 100B

Acid chlorides

Highly soluble intermediates for dyes, fibers and resins go commercial.

Two bifunctional acid chlorides, isophthaloyl and terephthaloyl chloride, made only in pilot-plant quantities until recently, are now available in semicommercial quantities.

Both are important raw materials for new synthetic fibers that possess unusually good chemical and thermal stability. As intermediates, they undergo typical acid chloride reactions and exhibit higher solubility and reactivity in many organic solvents than do the corresponding acids.

Because of their high solubility, they facilitate conversion to valuable derivatives such as polyesters and polyamides.

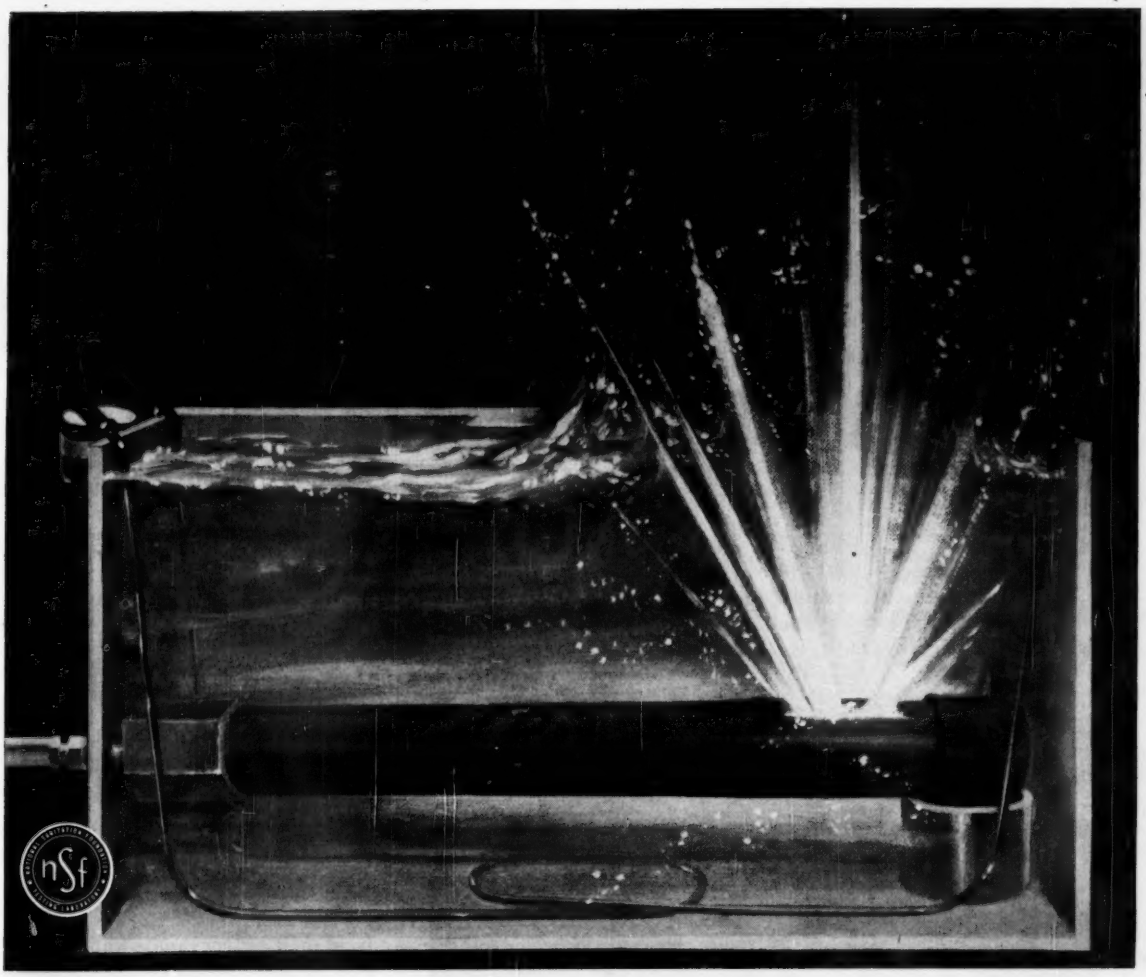
Iso- and terephthaloyl chloride have already found their way into the manufacture of dyes, synthetic fibers, resins, films and protective coatings. But they can also play a big part in such different areas

Newsworthy Chemicals

Page number is also reader service code number

Polyethylene-saran films simulate metal cans....98A
Aromatic ketone improves printing inks....98B
Multicell rayon simplifies manufacture of paper....100A
Zeolite crystals act as catalyst carriers, separate hydrocarbons....100B
Iso- and terephthaloyl chlorides now available....100C
Mo-W alloy powders make true solid solutions....102A
Epoxy resin for transparent castings....102B
Hydrazine diborane now available....102C
Epoxy coating doesn't require hardener before use....102D
Mold solvent marketed for sticky plastics....102E
Copper coating treats rubbery and metallic surfaces....102F

For more details use Reader Service Card



We rupture our plastic pipe so yours won't

This explosion marks the end of the short but useful life of a piece of USS National PVC Pipe. We deliberately burst it during a test with pressure that would exceed the strain of normal service.

The length of PVC Pipe was submerged in heated water; then more water was forced into the pipe until it burst. The pressure was much greater than specifications. Tests like this prove to us that the PVC Pipe we sell is more than strong enough for your job.

USS National PVC Pipe is highly resistant to corrosion from acids, alkalies, salt solutions, alcohols and other chemicals. It's easy to fabricate and join, has excellent impact resistance, and its smooth internal surface minimizes deposit build-up. USS National PVC Pipe is available in sizes from ½ inch to 12 inches in diameter, and Schedules A, 40, 80 and 120.

For information, write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. Ask for Bulletin #24. *USS and National are registered trademarks*

Watch United States Steel's special Christmas show, **The Coming of Christ**, in Color on NBC-TV, Wednesday, December 21, 8:30 P.M., E.S.T.

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • United States Steel Export Company, New York

as rubber chemicals, ultraviolet adsorbers, pharmaceuticals, and as cross-linking agents for polyurethanes and polysulfides.

Both come in prices upwards of $1/lb. but large commercial quantities are projected to be in the range of 35-50¢/lb. — **Hooker Chemical Corp., Niagara Falls, N. Y.** 100C

Alloy

Mo-W high-purity powders make solid solutions.

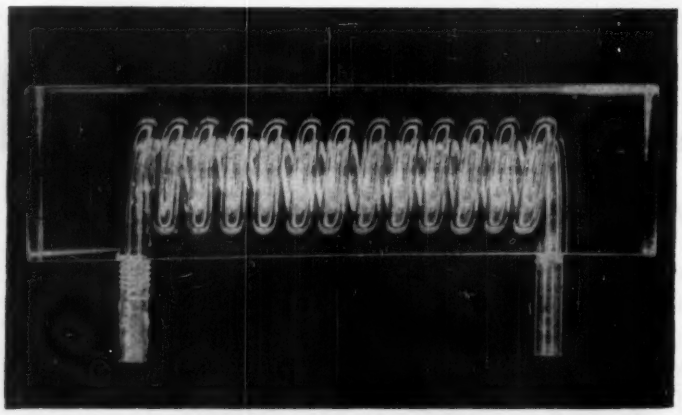
Two grades of molybdenum-tungsten alloy powders, MA-28 and MA-39, can give true solid-solution alloys of any composition.

Usually formed by hydrogen reduction of oxides or ammonium compounds of molybdenum and tungsten, these powders have been made via a new process that gives each particle the characteristics of a solid-solution alloy by eliminating the problems of particle segregation encountered in fabricating Mo-W mixtures.

The MA-28 grade contains a minimum of 99.8% Mo-W alloy with all impurities closely controlled. Designed primarily for powder-metallurgical processing into rod and wire, it can also be used for pressing and sintering into large ingot forms for forging, rolling and machining.

MA-39 grade, with a minimum of 99.9% Mo-W alloy, produces the best rolled sheet and rod products where extreme purity, low oxygen content or larger particle size are required.—**Sylvania Electric Products Inc., New York.** 102A

Transparent casting with epoxy resin



Maraglas epoxy resin can easily make crystal-clear castings such as the one shown. For this application—embedment of a spiral-shaped glass coil—five parts of Maraglas resin are blended with one part of marblette hardener #553 in a common mixer.

A conventionally fabricated mold is waxed and polished, and a parting coat is sprayed and allowed to dry for about 10 min. The glass spiral is then placed in this mold and the low-viscosity liquid mixture of resin and hardener is poured in. After several hours at 180-210 F., the cured casting is removed and any film left on it by the water-soluble parting can just be washed off.

This casting operation does away with vacuum equipment or other complex apparatus normally used. The finished casting transmits 90% light and exhibits a bubble-free, nontacky surface that won't crack or distort when exposed to extreme temperatures and humidity.— **Marblette Corp., Long Island, N. Y.** 102B

Briefs

Hydrazine diborane, structurally $BH_2—NH_2—NH_2—BH_2$, is a white, crystalline, free-flowing powder with a density of 0.91 grams/cc., and heat of formation at −30-Kcal./mole. Because of its hydrogen content, together with its chemical and thermal properties, hydrazine diborane is especially suitable for propellant chemistry. —**Callery Chemical Co., Pittsburgh.** 102C

Epoxy coating Humiseal Type 1F56, is a high-temperature rigid epoxy system of 100% solid content that doesn't require mixing with a hardener and may be used directly from the shipping container. — **Columbia Technical Corp., New York.** 102D

Mold release, called Mold Wiz AZN, is a new solvent especially developed for sticky plastic moldings such as isocyanate and epoxy applications including fiber glass-epoxy and isocyanate foams.— **Axel Plastics, New York.** 102E

Copper coating process, Cuprodine 5, increases coating adherence and gives great uniformity of color when applied to stainless steel wire and stampings. It acts as a lubricant on the steel to reduce scratching of the wire, pickup and wear on dies. In tire manufacturing, before molding and vulcanizing, the uniform Cuprodine coating prepares an excellent bonding surface for rubber. — **Amchem Products Inc., Ambler, Pa.** 102F

For More Information about any item in this department, circle its code number on the Reader Service Postcard (Page 243)

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TECHNICAL BULLETINS DESCRIBING H_2O_2

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You can have 'em—
They're FREE!

Years of experience in working with Hydrogen Peroxide have produced a wealth of information on this valuable compound, its properties, and reactions. Much of this information is available virtually exclusively from Becco. We've compiled a number of Technical Bulletins, which are yours free on request. Simply decide which ones you want, and mail the coupon below.

No. 2—Hydrogen Peroxide (general information)

No. 41—Becco H_2O_2 35% HP (high purity)

No. 42—Becco H_2O_2 35% Formula D (for preparing dilute solutions)

No. 46—Concentrated H_2O_2 (over 50% concentration)

No. 70—Becco Hydrogen Peroxide SP "100" (Super Pure, of virtually 100% concentration.)

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By "other", we mean "Other than Hydrogen Peroxide". Lots of otherwise knowing people labor under the impression that Becco makes only H_2O_2. Actually, there are quite a few "other" useful peroxides in Becco's catalog, some of which are especially suited to high-temperature oxidation reactions.

Look over the list below. Give you ideas? Remind you of a problem you've got? Either way, a note to Becco will bring you more information. Or, use the handy coupon.

UREA PEROXIDE—for use in hair dyeing and cold waving, disinfectants, hypo eliminators, and as a source of water-free H_2O_2.

SODIUM CARBONATE PEROXIDE—for compounding detergents and adhesives.

SODIUM PERBORATE—for use in dyestuff development, detergents, tooth-powders; as a mild bleaching agent and cold wave neutralizer.

CALCIUM PEROXIDE—for dough conditioning and in high-temperature oxidation reactions.

MAGNESIUM PEROXIDE—an antifermentative, for compounding antacids and laxatives.

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Nitrogen erupts after high-pressure tank ruptures.

ALLOY BOOSTS PROSPECTS FOR LIQUID GAS STORAGE

Pressure-vessel code changes are imminent following successful testing of tanks made from a 9%-nickel steel designed for ultralow temperatures.

"1,500 .... 1,800 .... 2,000 ...." The pressure built up as liquid nitrogen was pumped into a new cryogenic storage tank—built up until finally at 2,150 psi. the tank ruptured, spewing a towering pillar of rapidly vaporizing, frigid nitrogen.

Deeply significant to many areas of the chemical process industries, the test described above was part of a series designed to demonstrate the qualities of a little-used alloy—9%-nickel steel—that was developed specifically for cryogenic service at temperatures to −320 F.

The joint sponsors of the test—U. S. Steel, International Nickel and Chicago Bridge and Iron—wanted to demonstrate to the authorities who establish various pressure-vessel codes that large tanks and vessels made with 9-Ni steel are just as strong in the as-welded condition as those whose welds were stress-relieved after fabrication.

▶ **Cheaper Process**—Vessels built with quenched and tempered plate, as welded, are cheaper to build than those that require stress relieving of the welds, in an extremely hot oven. As vessel size increases and vessel fabrication has to be moved from the shop to the field, stress-relieving costs rise sharply.

Rectangular vessels, similar to those used on ships, and cylindrical vessels (used for land-based storage) were both tested. As-welded vessels outperformed stress-relieved vessels of each type.

The natural market that the companies hope to break into with the new tanks is that of storage and transport of liquid natural gas. The companies feel that 9-Ni can compete successfully with the present leader in the field—aluminum. Vessels fabricated from as-welded 9-Ni are said to be about 10% cheaper than Al, to be stronger, and to hold up better in case of fire.

▶ **Code Change Possible** — Code people, representing the ASME, Coast Guard, Maritime Board and other bodies, apparently feel that the change in ASME code for Unfired Pressure Vessels to permit as-welded construction will be approved upon formal application.

Vessels for cryogenic service are not necessarily required to withstand high pressures while in use—in fact, the whole principle of cryogenic storage is to use low temperature to liquefy the gases and thus obviate pressure. The use of the high pressures in the test was just to demonstrate the strength of the vessels under ultimate conditions.

Reasons for the heightened interest in low-temperature storage of gases (such as oxygen, nitrogen, methane, chlorine, ethylene and many others) are apparent from the following comparison between ambient and low-temperature oxygen storage.

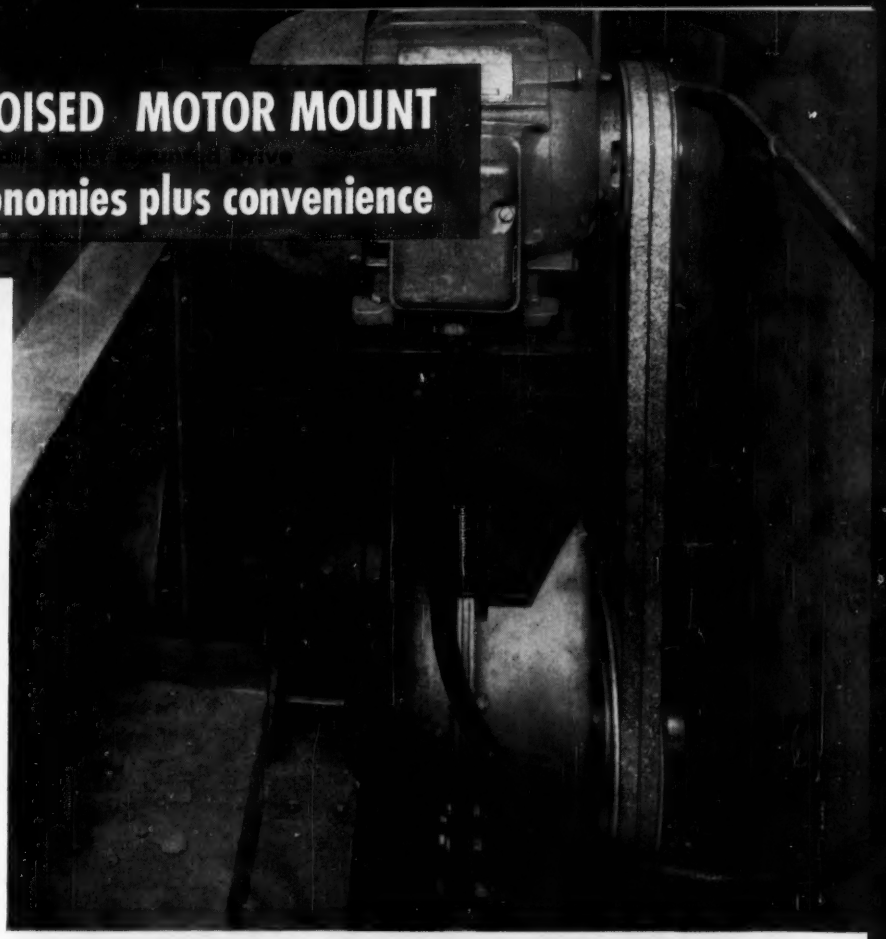
▶ **Huge and Heavy**—According to Chicago Bridge and Iron's John T. Horton, a storage tank to hold 25 million scf. of oxygen under six atmospheres pressure at ambient temperature would be a 200-ft. sphere. If built of high-strength T-1 steel, the sphere would require walls 1½-in. thick, weigh 2,000 tons, and cost $1¼ million.

For low-temperature liquid storage of oxygen, two concentric spheres would be used. The 9-Ni inner one would be only 39 ft. in dia.; the outer 45-ft. sphere would require only carbon steel. Total weight of the spheres plus insulation would be 145 tons; cost, about $100,000.

Low-temperature storage would also have a safety advantage, says Horton. The larger sphere, under six atmospheres pressure, would contain the explosive equivalent of 15,000 lb. of TNT as energy of

NEW FALK EQUI-POISED MOTOR MOUNT

gives unequaled economies plus convenience

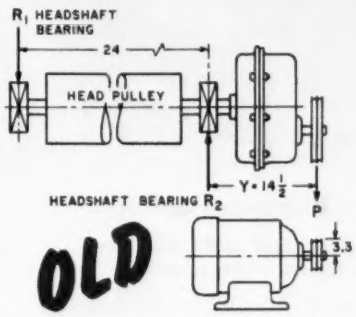


HOW A FALK EQUI-POISED MOTOR MOUNT REDUCES BEARING LOADS ON A DRIVEN MACHINE

GIVEN: Motor—15 hp, 1750 rpm, Frame 284U, Weight—320 lb.
Sheave diameters—6.6/9.4
Driven machine—belt conveyor with 24" center distance between headshaft bearings.

NOTE: Weights of 307J24 Shaft Mounted Drive, sheaves, and V-belts are eliminated from calculations because they remain constant; do not affect the comparison.

WITHOUT FALK MOTOR MOUNT



Torque at motor shaft = $\frac{63{,}025 \times 15 \text{ hp}}{1750 \text{ rpm}} = 540$ lb-in.

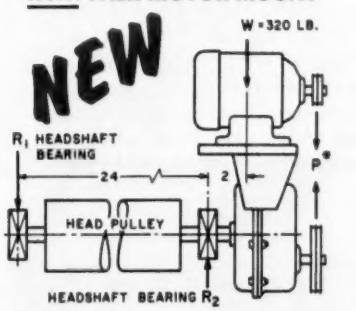
Belt pull (P) = $\frac{540 \text{ lb-in.}}{3.3''} \times 1.5$ Load Connection Factor
= 246 lb

$R_2 = \frac{246 \text{ lb} \times (24'' + 14.5'')}{24''} = 395$ lb

$R_1 = \frac{246 \text{ lb} \times 14.5''}{24''} = 149$ lb

(Check: 395 lb—149 lb=246 lb)

WITH FALK MOTOR MOUNT



*P = ZERO REACTION AT HEADSHAFT BEARINGS

V-belt pull has zero reaction on headshaft bearings. Therefore—

$R_2 = \frac{320 \text{ lb} \times (24'' + 2'')}{24''} = 347$ lb

$R_1 = \frac{320 \text{ lb} \times 2''}{24''} = 27$ lb

(Check: 347 lb—27 lb=320 lb)

Falk's new EQUI-POISED* Motor Mount is a rigid, all-steel weldment, pre-drilled for bolting standard NEMA foot-mounted motor (1/2 to 30 hp) directly to the steel frame of Falk Shaft Mounted, Flange Mounted and Screw Conveyor Drives. With it, motor can be mounted in almost any position around perimeter of reducer.

(*Balancing of forces.)

Substantial Savings for You

It saves engineering time required to design special motor bases and foundations...saves cost of labor and materials required to build special motor foundations...and saves on equipment costs by using a quality stock component. Further, its quick installation and easy maintenance mean added cost savings. The Motor Mount is a space saver, too. Where restricted space is a factor, ability to mount motor in any of several positions is an important convenience...For information on range of sizes, dimensions, etc., contact your Falk Representative or Distributor—or write direct for Bulletin 7100.

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compression vs. none in the low-temperature unit.

Total U.S. sales of 9-Ni (1958-59) were only about 1,000 tons. Most of it was used for relatively small process vessels in oxygen and nitrogen regenerating plants.—**International Nickel Co., Inc., New York.** 104A

Gravity system

Equipment continuously weighs a constant volume of material.

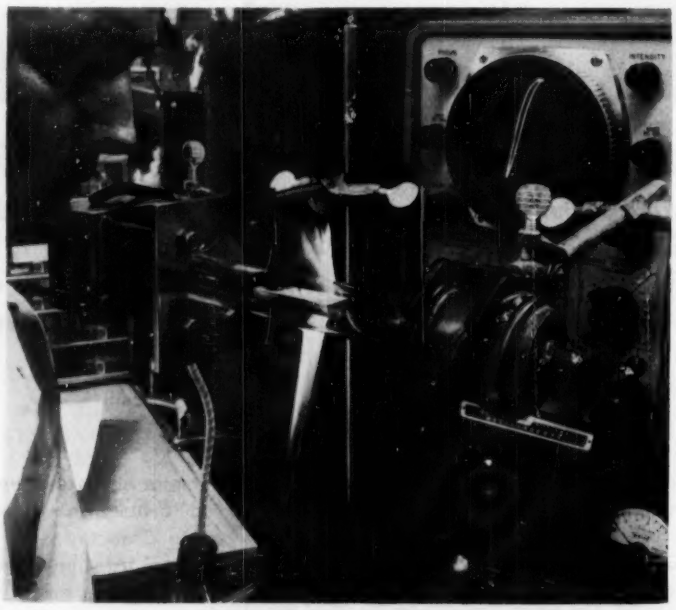
Designed to work directly with a process stream, a new specific gravity measuring system weighs a constant volume of liquids, slurries, suspensions, emulsions, whips and creams. Its continuous output signals can be used to indicate, record or control.

Gravity measurement is obtained from a pneumatic weight-transmitter and a specially designed stainless-steel tank. Weight of a constant volume in the tank is directly proportional to specific gravity, so readout is directly in specific gravity units.

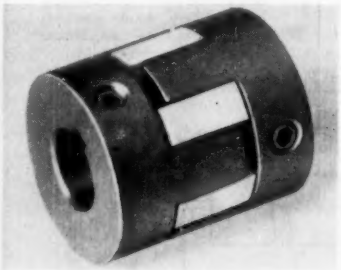
For materials containing entrained air, a closed tank is used. A probe and an air-vent valve maintain the liquid level by venting the top of the tank while maintaining an internal pressure. Other liquids are measured in a simple, open-top overflow tank. In both tanks, baffle-induced turbulence maintains solids in suspension.

Accuracy is claimed to be about ¼%; repeatability is one part in 2,000. The pneumatic output signal is essentially stepless, which permits smooth control of other equipment.—**Weighing & Controls, Inc., Hatboro, Pa.** 106A

Researchers put heat on transistor development



Silicon carbide, which in impure form is used as an abrasive in grinding wheels, has broken into the transistor field. Still in the laboratory stage of development, silicon carbide transistors can operate at temperatures well above those of the now-conventional germanium and silicon units. Researchers say silicon carbide test units operate efficiently at 670 F., have a potential upper limit near 1,000 F. Present germanium or silicon units, good to a maximum of 400 F., are used extensively in aircraft and space vehicles, which should benefit from the new transistor. —**Westinghouse Electric Corp., Pittsburgh.** 106B



Flexible coupling

Stainless steel and Teflon combine for corrosion resistance.

Pumps working in a corrosive environment can now be connected to drive-motors with chemically resistant couplings fashioned from stainless steel and glass-filled Teflon. Coupling halves are cast from stainless steel, are assembled around a molded self-lubricating spider of glass-filled Teflon, which eliminates need for external lubrication and also acts as an electric insulator between drive and pump.

Couplings, which are self-aligning within reasonable limits, may be removed from the shaft without dismantling the drive. Available in bore sizes from ⅜ to ¾ in., couplings weigh only 10 oz.—**Eco Engineering Co., Newark, N. J.** 106C

Paperboard drum

Release qualities make it good for asphalt, resins, waxes

A new paperboard drum is designed specifically to handle products that adhere to ordinary con-

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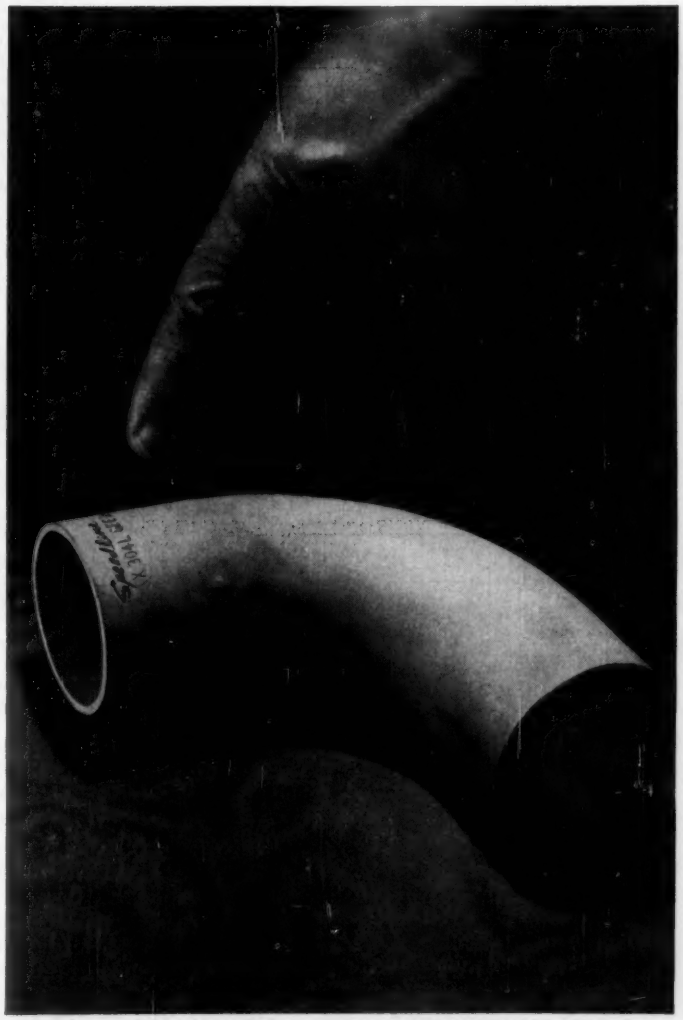

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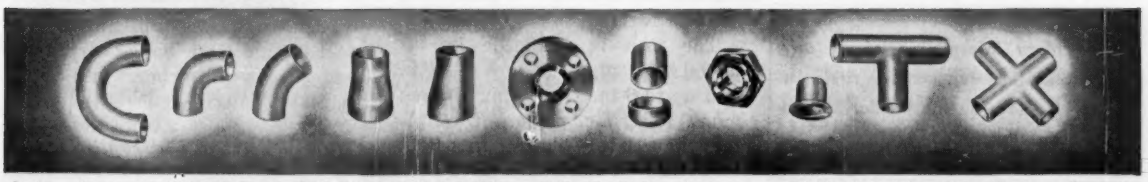

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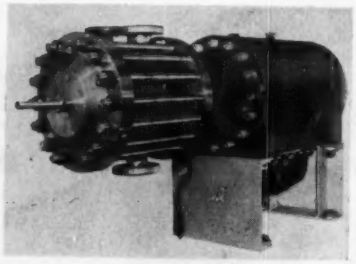
tainers, particularly those that solidify after being poured in liquid form. Principal feature of the new container is a patented release coating called Cellu-Kote.

Currently used largely for asphalt shipment, the drum has been tested for a variety of other materials. It can be made with either paperboard or metal tops and bottoms, can have aluminum foil between plies to serve as a moisture barrier, or can be supplied with a polyethylene liner.

Drum blanks are shipped flat and palletized so that a stack of 1,000 drums requires less than 16 sq. ft. of floor space. A special machine assembles the drum at the customer's plant, as needed.

The standard drum of 100-lb. capacity has a 13-in. dia., ranges from 22 to 25 in. high, depending on pouring temperature. Special sizes to 300 lb. are available, and a 500-lb. unit is under development. — **The Mead Corp., Cincinnati.** **106D**



Cryogenic pump

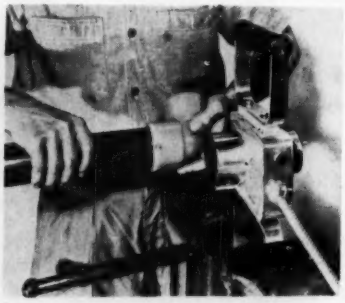
High-pressure, high-flow unit handles 120,000 cfh. nitrogen.

Working at up to 15,000 psi., a new high-pressure, high-flow cryogenic pump is designed with three distinct thermal sections. The lubricated drive-end operates at ambient temperatures, thus requires only normal lubricants.

The cryogenic section that pumps the liquefied gas needs no lubrication, operates at very low temperatures. An intermediate section contains the housing seals, provides a thermal barrier between the temperature extremes.

The pump is a 5-cylinder, fixed-displacement type that operates on a suction pressure as low as 10 psi. It contains an internal manifold that requires only one discharge connection. — **The Cosmodyne Corp., Hawthorne, Calif.** **108A**

For More Information about any item in this department, circle its code number on the Reader Service Postcard Page 243.



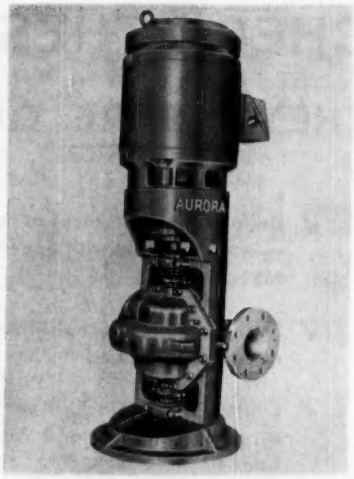
Pipe-joint heater

Solvent-resistant plastics are joined by new heating tool.

Plastic pipe and fittings that are difficult to join by solvent cementing or threading can be assembled quickly with a new portable heat tool. Unit is said to make a leakproof bond that is immediately ready for pressurizing.

Called Thermo-Seal, the aluminum tool has tubular electric heater elements cast internally. It exhibits two surfaces upon which pipe ends and fittings' sockets are simultaneously heated to fusing temperature. The bore of the socket and the mating surface of the pipe, thus heated, are joined. Within ten seconds, a permanent bond is formed.

The unit is available in two models, for pipe sizes up to 2½ in. and up to 6 in. Operating on common 110-v., a.c. power, it weighs less than 10 lb.—**Tube Turns Plastics, Inc., Louisville, Ky.** **108B**



Vertical pump

Centrifugal, split-case unit designed for compact service.

Said to be especially suitable for applications requiring extreme compactness, a new centrifugal pump is vertical, single-stage type. The case is split parallel with the impeller shaft and has the suction and discharge flanges located in the vertical base section.

Inspection and maintenance is facilitated because rotating unit can be removed without disturbing suction or discharge piping. Capacities range to 6,000 gpm., heads to 380 ft. — **Aurora Pump Div., The New York Air Brake Co., Aurora, Ill.** **108C**

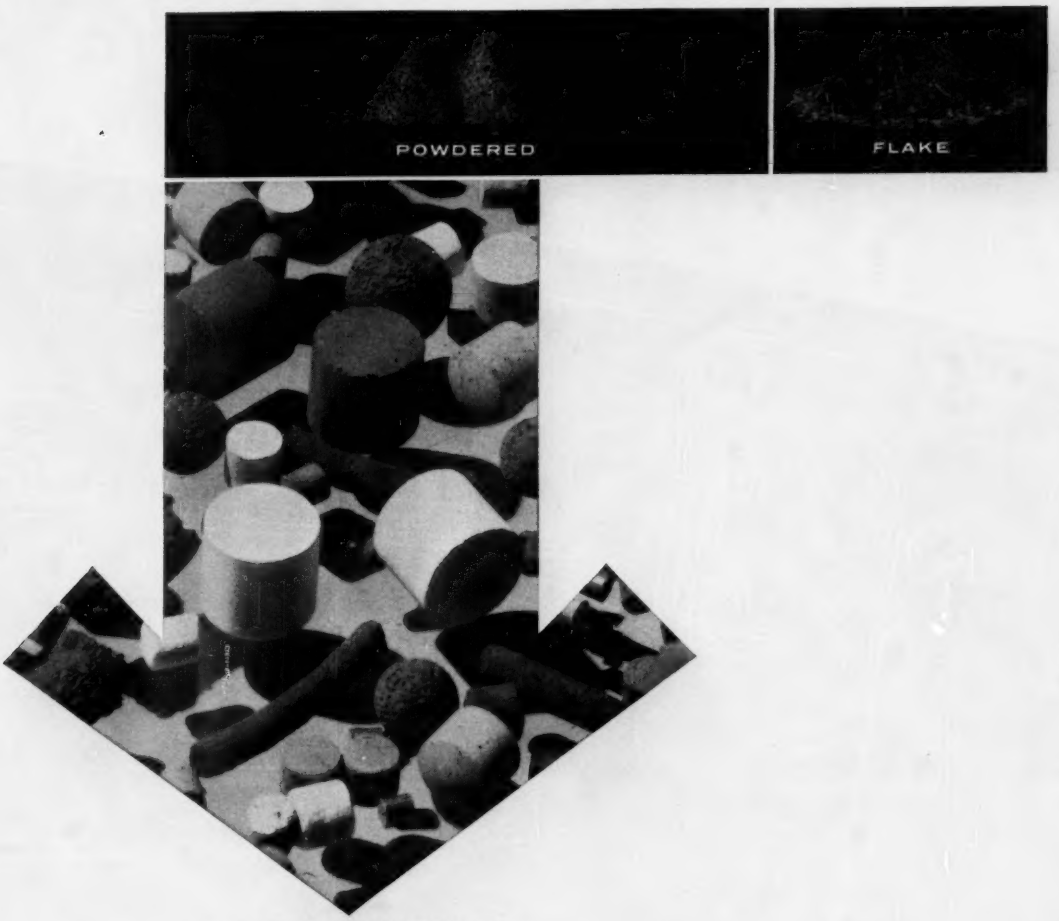
Electric truckster

Unit is designed for light hauling and personnel carrying.

Hop into this electric truckster with another passenger and 500 lb. of cargo—it will travel about 40 miles at speeds to 7 mph. before its batteries need recharging. The 3-wheel model will operate in 40-in. passageways.

The truck has an all-welded steel frame and body, airplane-type shock absorber, and mechanical brakes on both rear

MORE NEW EQUIPMENT
(Continued on page 213)



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Nickel Carbonate	Nickel Formate	Nickel Nitrate
Nickel Sulfate	Sodium Methoxide	Zinc Nitrate

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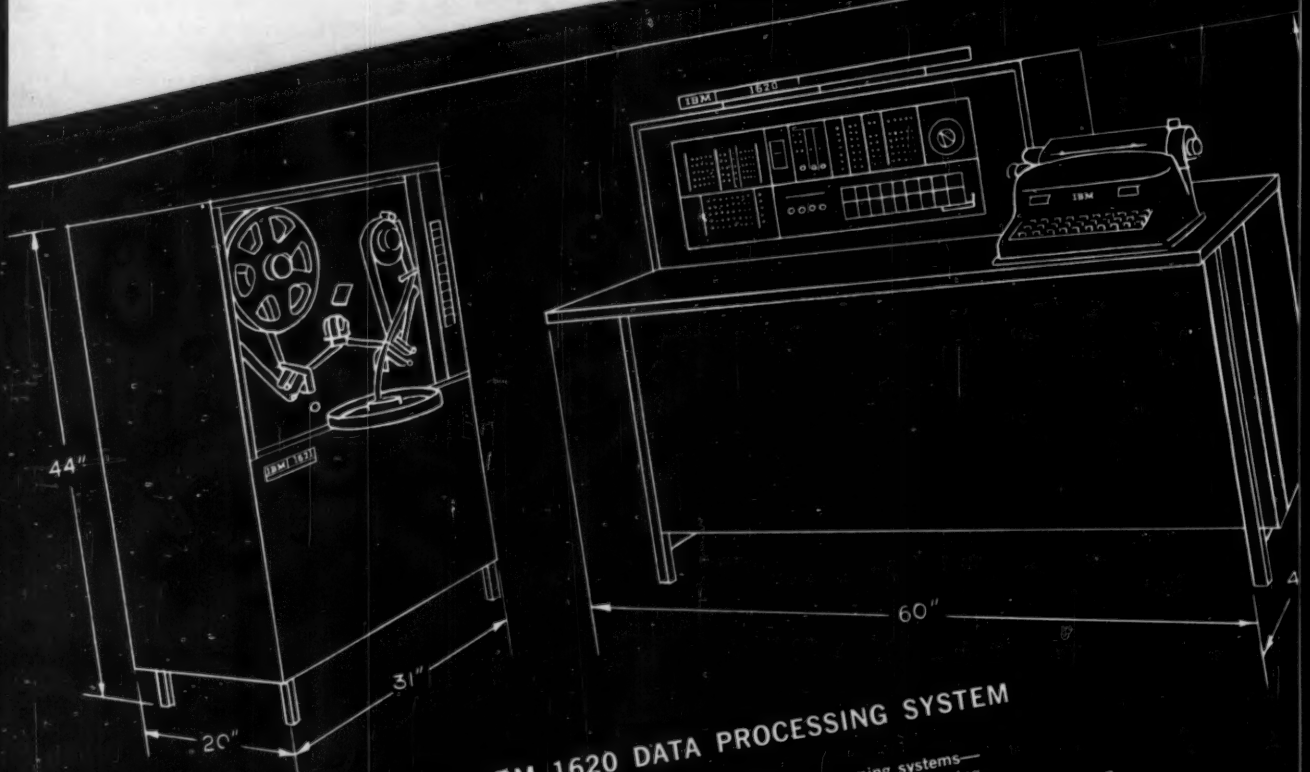

SPECIFICATIONS: IBM 1620 DATA PROCESSING SYSTEM

Core storage—20,000 digits
Automatic operation—stored programming
High computing speed—20 microsecond machine cycle
Powerful instructions with two data addresses
Decimal and alphabetic
Variable field and record length—any size numbers

Advanced programming systems—
Fortran and symbolic programming
Compatibility with other computers through Fortran
Simple console with logging features
Self checking throughout
Transistorized circuitry—
compact, economical, reliable
Paper tape input and output

The 1620 will meet technical computing requirements too complex for the conventional desk-type calculator. It provides many advantages of larger systems at a much lower cost. In addition, it can be used to support other data processing systems such as the IBM 650, 704, 705, 709, 7070 and 7090.

Information enters the system from the typewriter of the 1620 Central Processing Unit, or from the 1621 Paper Tape Reader. Output is to the typewriter or 961 Tape Punch.

Machine	Weight in lbs.	Current Requirements	Power cord	Interconnecting cable	Heat Load Specification BTU/Hr
1620	1,000	20 Amps., 115 Volts, single phase	10′ 3-Wire for 115 and 230 Volts	10′ signal	5,000
		10 Amps., 230 Volts, single phase		10′ power	
		6.5 Amps., 208 Volts, three phase	10′ 4-Wire for 208 Volts	—	2,000
1621	280	—	—	—	

FREE YOUR ENGINEERING STAFF FOR MORE CREATIVE WORK . . .

IBM 1620 LOW-COST, DESK-SIZE COMPUTER

RELIEVES YOUR STAFF OF TIME CONSUMING WORK

...SOLVES WIDE RANGE OF SPECIALIZED PROBLEMS

Problems that used to tie up your engineering staff for days can now be solved . . . with electronic accuracy . . . in minutes! The IBM 1620 is a low-cost, desk-size engineering computer that solves a tremendous range of chemical engineering problems quickly and easily. The 1620 offers you an economical way to increase staff productivity, helps pave the way for profitable growth.

The 1620 is easy to learn, easy to operate, easy to communicate with. It adapts readily to such specialized problems in the chemical industry as design development, blending problems involving matrix arithmetic, research calculations with differential equations, problems in kinetics, reactor design, statistical design of experiments, and evaluation studies employing techniques such as regression analysis.

IBM also makes available a comprehensive library of mathematical routines and programs as well as reliable customer engineering. These services supporting the 1620 are an important part of IBM Balanced Data Processing. They make it easy for you to make full use of the 1620 in your operations without delay. Like all IBM data processing equipment, the 1620 may be purchased or leased.

BALANCED DATA PROCESSING

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Dept. 805
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Please send me further information and complete specifications for the IBM 1620 Engineering Computer. I am particularly interested in:

_____
(engineering application)

NAME _____

POSITION _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

Some Straight Talk On Steam Trap Capacity

...or pulling away the curtain of confusion that surrounds steam trap capacity ratings.

Unfortunately, for the steam trap buyer, the subject of steam trap capacity has become cloudy and confused by a landslide of claims, counterclaims and inconsistent "standards" for measurement. So let's take a cold hard look at this subject so vital to the efficient operation of your plant.

What Determines Steam Trap Capacity?

There are three factors that determine the capacity of a steam trap:

1. The area of the orifice.
2. The density of the condensate.
3. The pressure differential across the trap.

Let's take a closer look at each of these:

Area of orifice is usually specified by the trap manufacturer or can be calculated from the diameter. Nothing complicated here.

Density of condensate depends on temperature. A cubic foot of cold water weighs 62.4 lbs. At 250° F. or 15 psi, it weighs less than 59 lbs. This is important. Don't overlook it.

Pressure differential across the trap is most significant. And it is complicated by the many factors that affect it, such as:

• 1. Pressure drop between unit drained and the trap when the trap valve is open.

2. Distance the trap valve is moved from the valve seat.

3. Back pressure on the trap with orifice closed; i.e., return header pressure.

4. Increase in back pressure produced by condensate and flash steam flowing in the discharge line. This in turn is affected by the diameter and length of the discharge line, plus friction caused by valves and fittings.

Orifice Capacity Vs. Steam Trap Capacity

Figure 1 shows a ½" diameter sharp-edged orifice at the end of a pipe filled with cold water at 15 lbs. pressure. The capacity of this orifice, using a .61 coefficient of flow would be 8,800 lbs. per hr. Now, would this ½" orifice if used in a ¾" steam trap installed as shown in Figure 2 provide the trap with a continuous discharge capacity of 8,800 lbs. of hot condensate per hour? The answer is "no". And here are some of the reasons why:

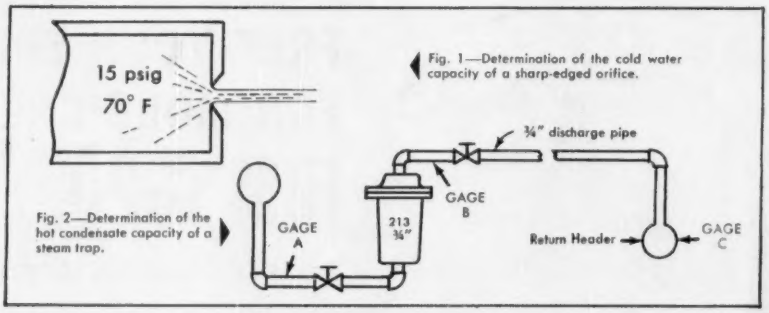


Fig. 1—Determination of the cold water capacity of a sharp-edged orifice.

Fig. 2—Determination of the hot condensate capacity of a steam trap.

Density of condensate. As pointed out above, cold water weighs 62.4 lbs. per cu. ft. At 15 lbs. pressure and 250° F. water weighs less than 59 lbs. per cu. ft. This difference in density alone reduces the lbs. per hour capacity of the orifice by over 5%.

Pressure differential across the trap. With the trap valve closed we have a static pressure differential of 15 psi. The trap valve must be able to open against this pressure. However, this is not the pressure differential that will determine the capacity of the trap valve.

The ¾" discharge line will be full of a mixture of flash steam and condensate. To keep this mixture flowing from the trap outlet to the return line requires a pressure differential. In actual capacity tests run as shown in Figure 2 Gage B at the trap outlet registered 11 lbs. back pressure. Thus the true pressure differential across the trap was about 4 lbs. Under these conditions the measured capacity of the trap was 4,340 lbs/hr. or just about half of the capacity of the ½" orifice for cold water.

How Armstrong Determines Capacity Ratings

Armstrong trap capacity ratings are based on hundreds of tests under actual operating conditions. In these tests, the condensate used was at the steam temperature corresponding to the test pressure. Thus, the capacities determined take into account the pressure drop that occurs when the trap orifice opens and the choking effect and back pressure of the flash steam. Actual installation hookups were used so that pipe friction in both inlet and discharge lines as well was reflected in the results.

Let's go back to the example cited above and in Figure 2. The trap referred to is an Armstrong No. 213. While it did test out at 4,340 lbs. per hour for a static pressure differential of 15 psi, it is rated in the catalog at only 3900 lbs. per hour for this pressure—just to be on the safe side.

For the trap buyer, this means that Armstrong Steam Trap capacities are based on handling condensate at steam temperature for the stated static steam pressure differential under actual working conditions.

Capacity ratings which don't take into account all of the variables will be misleading and may lead to the selection of undersized traps. So whenever you specify or buy traps be sure that the capacity ratings you work from are realistic. One way to be sure is to select Armstrong Traps with *guaranteed* capacity ratings.

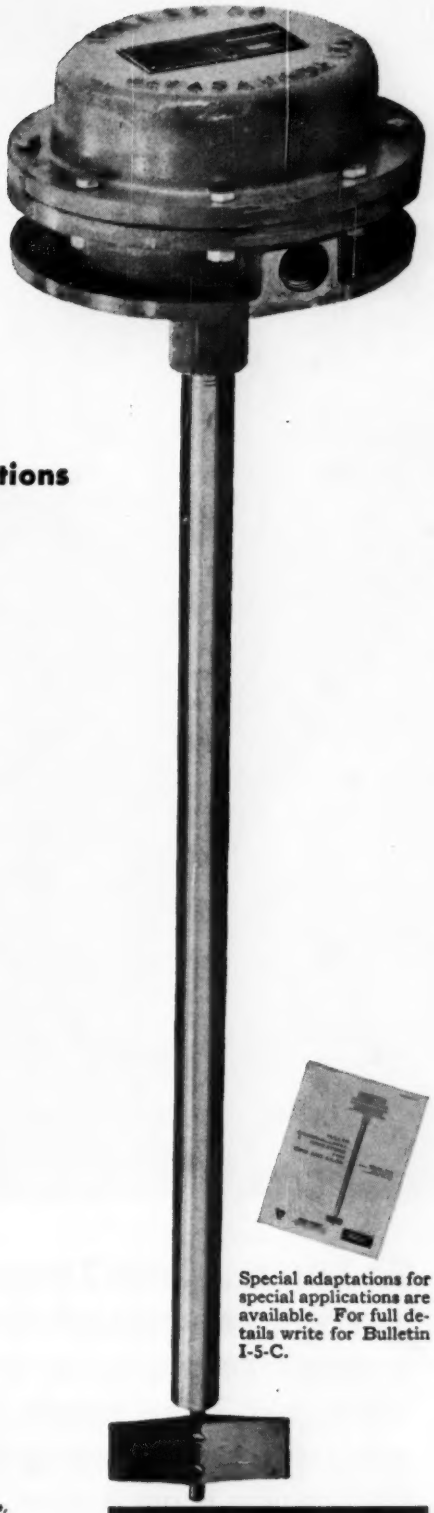
* * *

Additional information on trap capacity ratings, plus data on how to correctly size, install and maintain steam traps for any pressure, any temperature and any load, are presented in the 48-page Armstrong Steam Trap Book. Ask your local Armstrong Representative for a copy or write:

Armstrong Machine Works
8588 Maple Street
Three Rivers, Michigan

ARMSTRONG STEAM TRAPS

FULLER material-level indicators for bins and silos



For General Purpose and Hazardous Dust Locations

The Fuller Material-Level Indicator is a reliable high-level/low-level indicator that provides automatic control when a desired maximum or minimum level of material is reached.

The Material-Level Indicator automatically shows the level of pulverized, fine, crushed and granular materials—in a bin or silo—and readily "takes command" of such equipment as feeders, valves, elevators, and conveyors by starting or stopping equipment drive motors when a predetermined material level is reached.

Engineered and built for sustained operation over long periods of time, the sturdy Material-Level Indicator always registers true indication, regardless of momentary surges of bin material or the settling action of aerated, pulverized material.

Fuller Material-Level Indicator's Operation

A sensing paddle, located at the desired material level, is constantly rotated by a shaded pole induction motor located in the casing outside the bin or container. The motor and its reduction gears are mounted on an extension of the paddle shaft. Whenever material restrains the paddle from turning, the motor and its mounting revolve about the drive shaft, actuating two switches mounted on the base of the indicator.

When material falls away from the paddle, an adjustable tension spring returns the motor and its frame to the initial position, releasing the switches and causing the motor to turn the paddle again.

For high-level indication or control, the motor runs continuously until paddle rotation is impeded by the rising level of material.

For low-level indication or control, the paddle is restrained by the material and in turn restrains switches until the material falls below the paddle. When this happens, an adjustable tension spring returns the motor assembly to the starting position, releasing the switches and again starting paddle rotation.

Model SG-4 is designed for general purpose applications; SG-4 is UL approved for hazardous dust locations, Class I, Group D and Class II, Groups E, F, G.

Special adaptations for special applications are available. For full details write for Bulletin I-5-C.

For full details and specifications on the complete Fuller line, see Chemical Engineering Catalog

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2636
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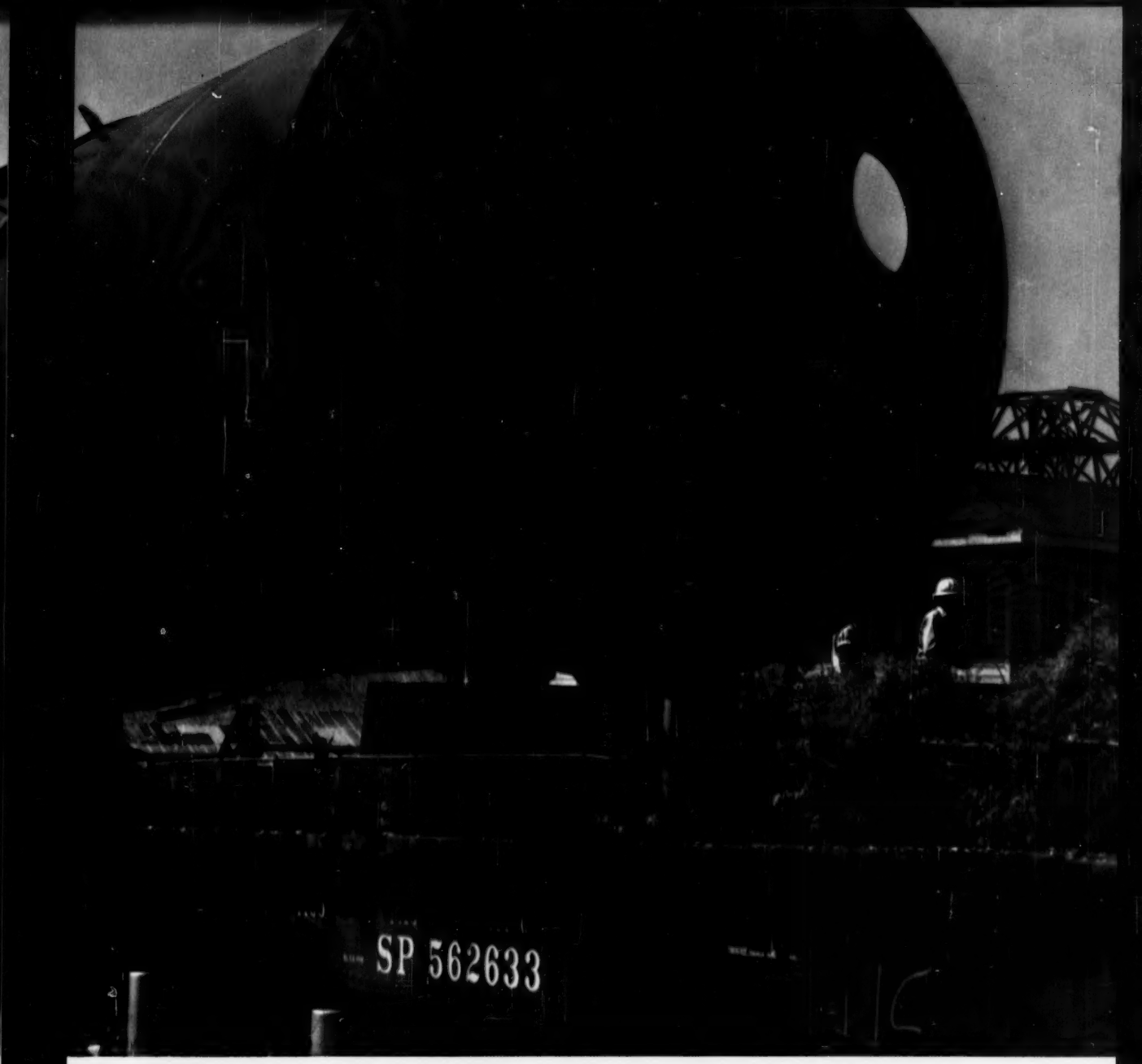
pioneers in harnessing AIR

So Long . . . Until Tomorrow It took five flat cars to ship this 195 foot-long fractionating column from our Orange, Texas, plant. Even the Texans thought it was a whopper, but tomorrow we'll be fabricating bigger ones—that's the way it goes. ☐ This column went to a leading refinery where it produces high purity isobutane, a component of premium gasoline. ☐ The 12-foot diameter steel column is made up of 20 rings or sections, each ¾ of an inch thick. The rings are welded together, then welded to a 20-foot skirt which supports the tower in its upright position. After fabrication the column was stress relieved.



Our Orange, Texas plate shop can handle custom plate work of all kinds and sizes. We have experienced men and the right equipment, high capacity cranes, giant presses and bending rolls, the latest welding equipment, mammoth car bottom furnaces, and complete inspection facilities. We can ship by rail, truck or barge. And anything we make, we can erect. ☐ Write for our booklet on plate fabricating facilities and services.

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USS

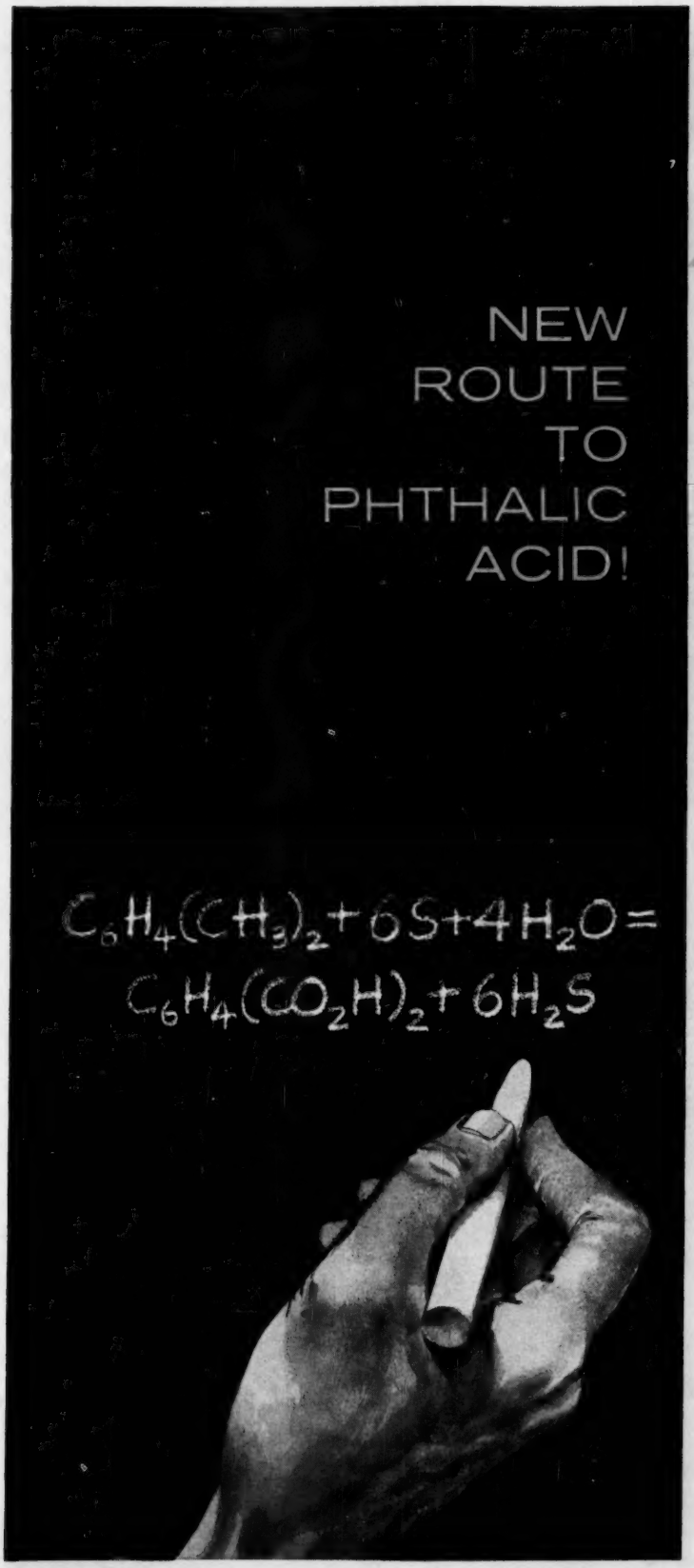
GET THE MOST READABLE SCALE ON THE MARKET

The new Taylor 210T TRANSCOPE® Transmitter is only 7″ x 9″ x 4″. Yet you can read the big 11¾″-long scale up to 35 feet away. New tape drive or with optional servo-driven indication, these low-cost, motion-balance pneumatic transmitters have ample power for process alarms, digital encoders, potentiometers and other auxiliary functions — *with no loss of accuracy.* Transmitted signal remains within ½% of the input signal. Threshold sensitivity is 0.1%.

Other features of the 210T TRANSCOPE Transmitter include the weatherproof case which is split diagonally to make adjustments easily accessible. Single package pneumatics, encapsulated movements and actuating element are easily removed and replaced for on-the-job maintenance. Designed for Gage Pressure, Volumetric Pressure, Volumetric Load and Temperature. Non-indicating model (211T) also available.

Ask your Taylor Field Engineer or write for **Bulletin 98385.** *Taylor Instrument Companies, Rochester, N.Y., or Toronto, Ont.*

Taylor Instruments **MEAN ACCURACY FIRST**



SULPHUR
helps to create
headline products

In a report to the Petroleum Division of the ACS, Dr. William G. Toland of the California Research Corporation recently announced the development of a new method for producing Phthalic Acid, with the following over-all reaction:

$$C_6H_4(CH_3)_2 + 6S + 4H_2O = C_6H_4(CO_2H)_2 + 6H_2S$$

Note that the presence of Sulphur right smack in the middle of this reaction is necessary for its completion. The Sulphur leaves the process at this point. The hydrogen sulphide can be oxidized to elemental Sulphur and returned to the initial reaction. It is thus operable in a closed cycle.

According to Dr. Toland, who developed this new route to phthalic acid, the process is simple and capable of high recoveries.

Here is another good example of how strongly Sulphur is in the processing picture. Together with its many derivatives it enters into countless reactions.

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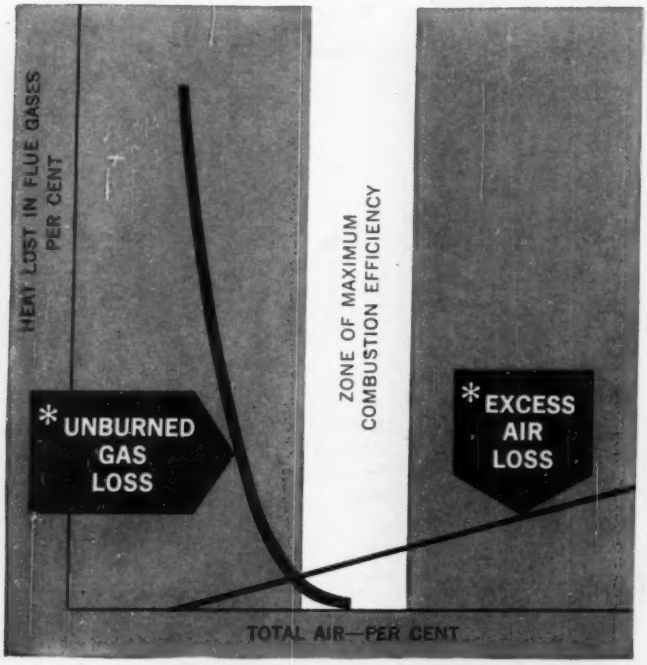
You must know BOTH* to get maximum combustion efficiency!

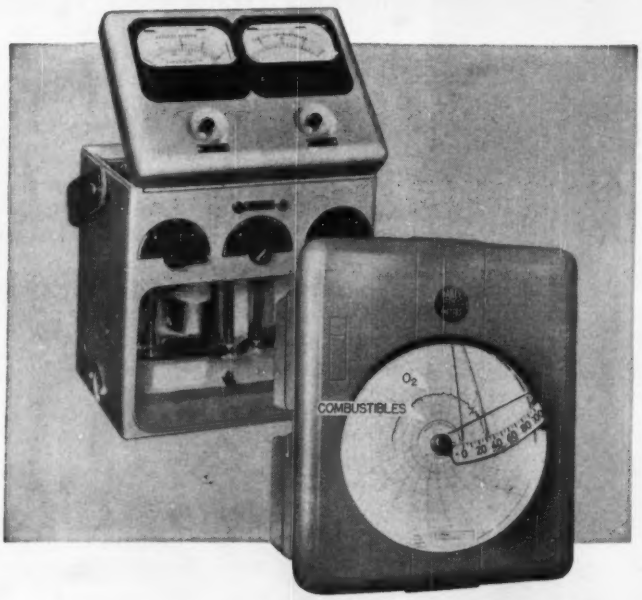

HEAT LOST IN FLUE GASES PER CENT
ZONE OF MAXIMUM COMBUSTION EFFICIENCY
* UNBURNED GAS LOSS
* EXCESS AIR LOSS
TOTAL AIR—PER CENT

How much money is going up the flue in *unburned fuel* losses? Is too much air resulting in excessive *heat* losses?

You must know *both* facts—simultaneously—to get optimum combustion. No instrument that measures only one of these interdependent factors can give you the full information you need.

Bailey offers a choice of two direct ways to maintain a continuous and simultaneous double check on these factors that determine combustion efficiency. The portable, lightweight Bailey HEAT PROVER Analyzer indicates both; the Bailey Oxygen-Combustibles Analyzer-Recorder records both on a single chart. Both instruments measure excess air, regardless of fuel or fuels being burned, and per cent of combustibles in flue gas.

Either of these Bailey instruments can save you far more than their cost in spotlighting combustion inefficiencies. Ask your Bailey engineer or write for product specifications.



2 DIRECT WAYS
to measure both combustibles and oxygen simultaneously

PORTABLE INDICATOR—Self-contained, lightweight, Bailey HEAT PROVER Analyzer enables quick, easy check on combustion conditions. Dual range dials for greater accuracy and readability.

PERMANENT RECORDER—Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart . . . is designed for permanent installation . . . helps maintain optimum ratio continuously.

* Unburned gas loss and excess air loss.

CP 112-1

Chemical and Petroleum Division

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In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

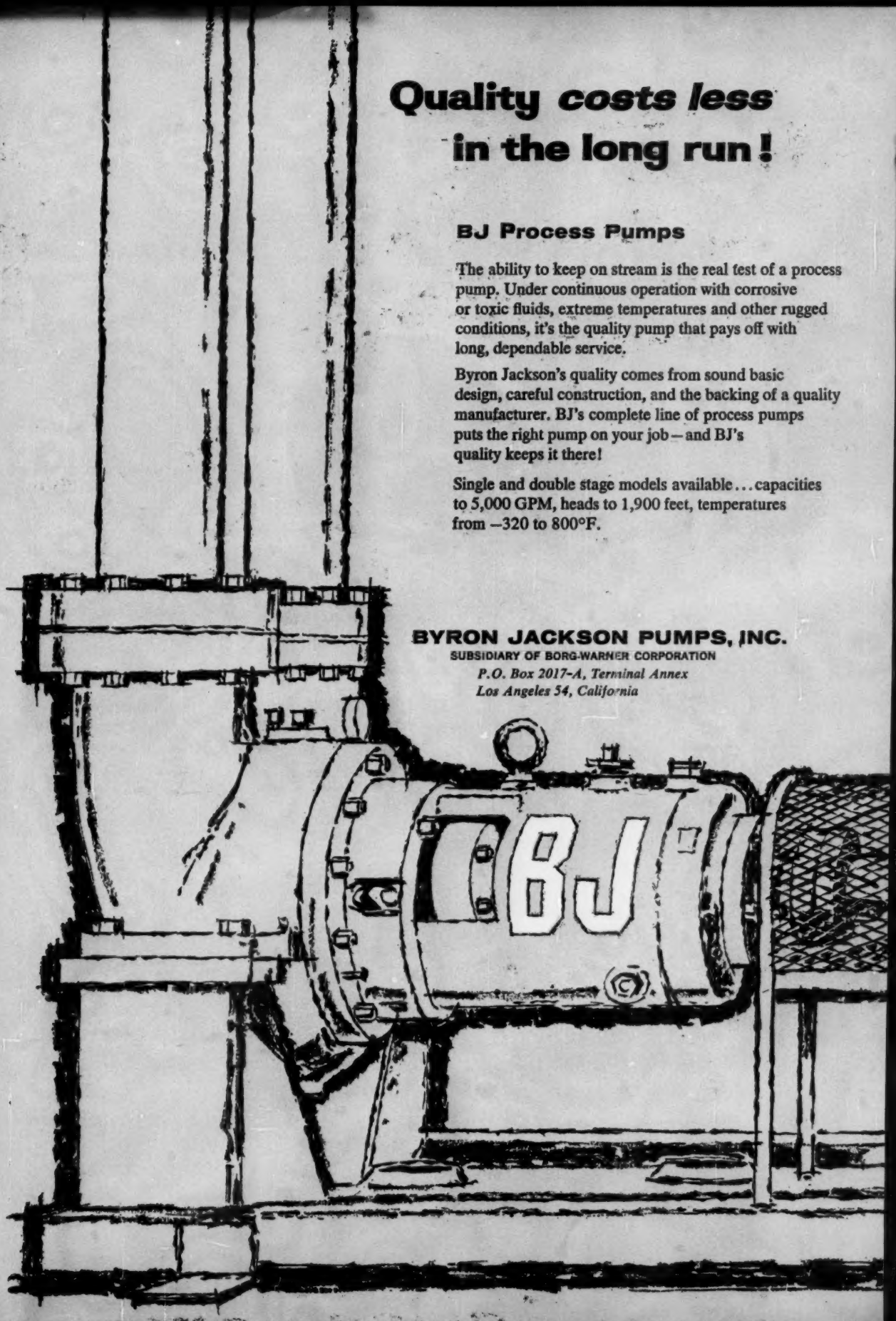
Quality *costs less* in the long run!

BJ Process Pumps

The ability to keep on stream is the real test of a process pump. Under continuous operation with corrosive or toxic fluids, extreme temperatures and other rugged conditions, it's the quality pump that pays off with long, dependable service.

Byron Jackson's quality comes from sound basic design, careful construction, and the backing of a quality manufacturer. BJ's complete line of process pumps puts the right pump on your job—and BJ's quality keeps it there!

Single and double stage models available... capacities to 5,000 GPM, heads to 1,900 feet, temperatures from –320 to 800°F.



BYRON JACKSON PUMPS, INC.
SUBSIDIARY OF BORG-WARNER CORPORATION
P.O. Box 2017-A, Terminal Annex
Los Angeles 54, California

CORROSION meets its match in Alcoa aluminum conduit

Here's an electrical rigid conduit that you can install and forget.

Alcoa aluminum conduit solves most corrosion problems in and around chemical plants.

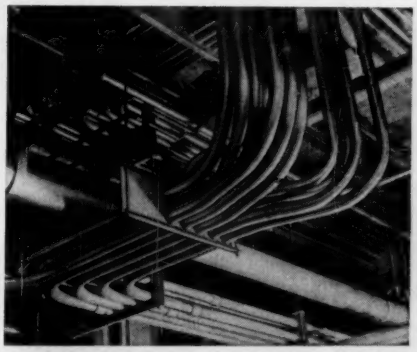
Aluminum protects itself Unlike other conduits, which require some kind of coating, aluminum forms its own protective film. This film forms naturally in the atmosphere and in the presence of oxidizing agents. Damaged spots are self-repairing—almost instantly! The natural oxide coating on aluminum takes the place of factory coatings on conventional conduits and only under unusual conditions is any other protection required.

Other advantages Corrosion resistance is just one good reason for selecting aluminum conduit. Its light weight (about ⅓ as much as steel) makes it easier to handle and install. Alcoa aluminum conduit is also nonmagnetic and non-sparking.

How about cost? Consider initial cost, savings in installation and maintenance, and service life. You'll see that Alcoa aluminum electrical rigid conduit stacks up as a sound investment.

More information For specifications, or answers to specific questions about the use of aluminum conduit in corrosive environments, contact one of our nearby representatives. Or write to Rome Cable Division of Alcoa, Dept. 22-120, Rome, New York.

ROME CABLE
DIVISION OF **ALCOA**



NO CORROSION despite moisture, chemicals and vapors in the basement of this sewage disposal plant in Cleveland. Installed in 1932, this Alcoa conduit still looks almost like new.

This pump can give you a price advantage!

The Goulds-Pfaudler glassed pump cuts pump replacement and maintenance costs for many companies making cosmetics, drugs, plastics, paints and other products requiring abrasive or corrosive pumpage. In these industries, where pump life is normally measured in months—or weeks—the Goulds-Pfaudler pump lives on and on.

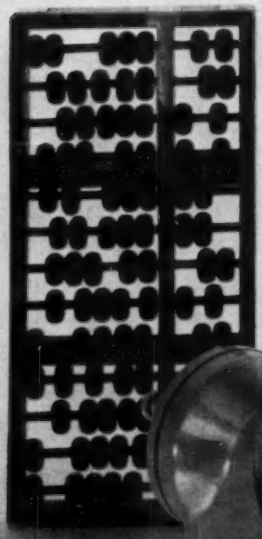
Why? Because it resists corrosion by all acids, except HF, up to 350°F and alkalis at moderate temperatures. Because only severe mechanical impact can damage its glassed surface, and then only locally since the surface will not crack or shatter. Because it withstands quick changes in temperature—up to a 100°F differential under ordinary operating conditions.

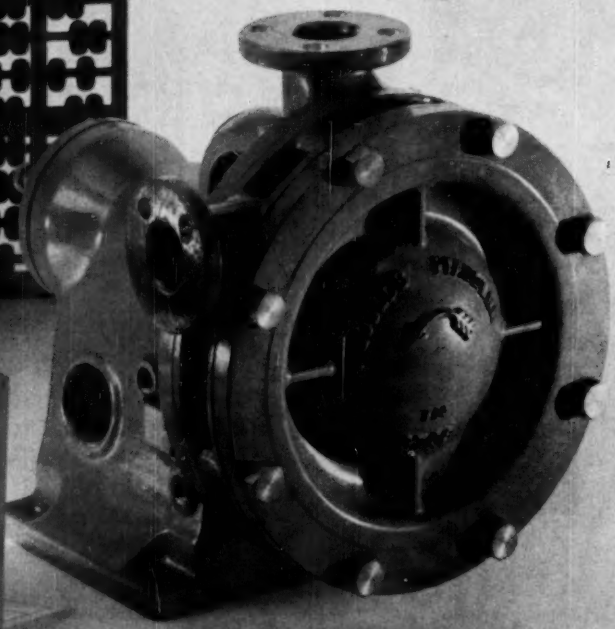
The Goulds-Pfaudler glassed pump also cuts production costs in other ways. It won't, for example, contaminate your product. It exerts no catalytic effect. Products won't stick to it, causing shutdowns for cleaning.

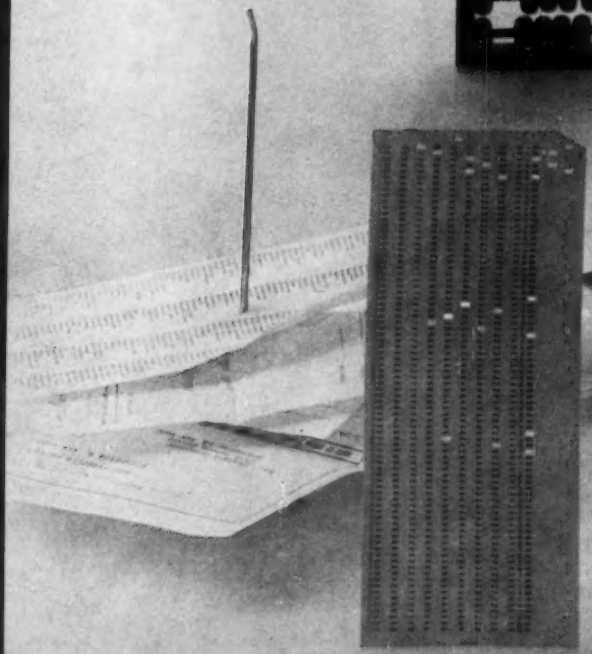
Yes, this pump could be giving your competitors a cost advantage. *But only if it's pumping their slurries and corrosives and not your own.*

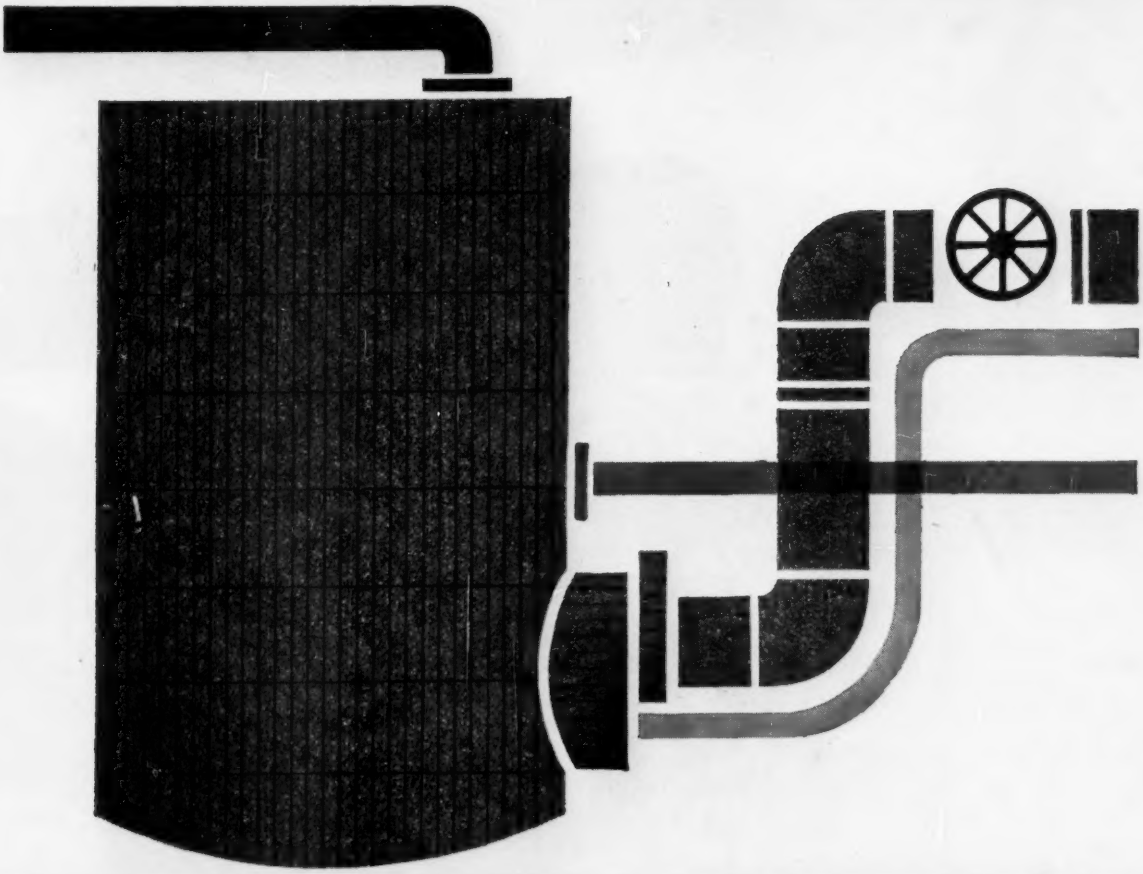
For further details, write for Bulletin 725.2. Goulds Pumps, Inc., Dept. C-4, Seneca Falls, N. Y.

GOULDS PUMPS









FOAMGLAS® Insulation works for AMERICAN CYANAMID CO.

EVIDENCE: In 1951, American Cyanamid Co.'s Linden, N.J., plant selected FOAMGLAS insulation to solve a number of high cost insulation maintenance and replacement problems.

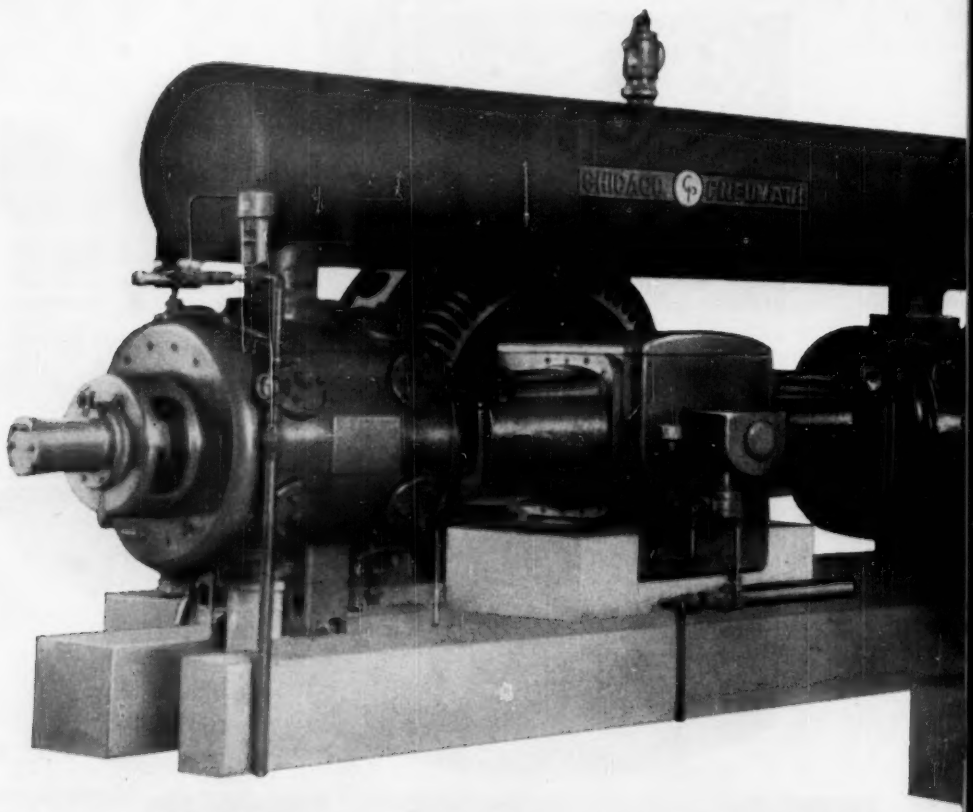
FOAMGLAS handled applications ranging from a brine cooler and feeder lines to steam lines operating up to 390°F—both indoors and out. The closed cell structure of FOAMGLAS insured constant insulating performance because moisture was kept out. The insulation has withstood the acid atmospheres in the plant—and with moisture and acids sealed out, external corrosion of piping and equipment has virtually been eliminated. FOAMGLAS has shown no rotting or deterioration, and maintenance has been almost nonexistent. The incombustibility of the insulation has been an important safety factor. Because of such performance, American Cyanamid has continued to use FOAMGLAS in this and other tough industrial applications even today.

See how FOAMGLAS can end insulation maintenance and replacement in *your* plant. Write for our American Cyanamid Case Study report and our Industrial Insulation Catalog. Pittsburgh Corning Corp., Dept. H-120, One Gateway Center, Pittsburgh 22, Pa. In Canada: 3333 Cavendish Blvd., Montreal, Quebec.

Pittsburgh Corning makes available a complete line of accessory materials for use with FOAMGLAS insulation. Write for Data Sheets.

PITTSBURGH PC CORNING

If your process requires oil-free air or gas,



you need . . .

CP OIL-LESS COMPRESSORS

Where air must be oil-free, CP offers a choice of three basic designs of Oil-less Cylinder Compressors . . . your assurance of the "right" construction for all service conditions. CP Oil-less Cylinder Compressors can be furnished with tailrods and outboard crossheads to fully support the pistons on all horizontal compressors; distance pieces between cylinder and frame to insure the *absolute* in oil-free air; and a choice of carbon or Teflon* rings and packing. *T.M. of du Pont

For complete information, write:

Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, New York.

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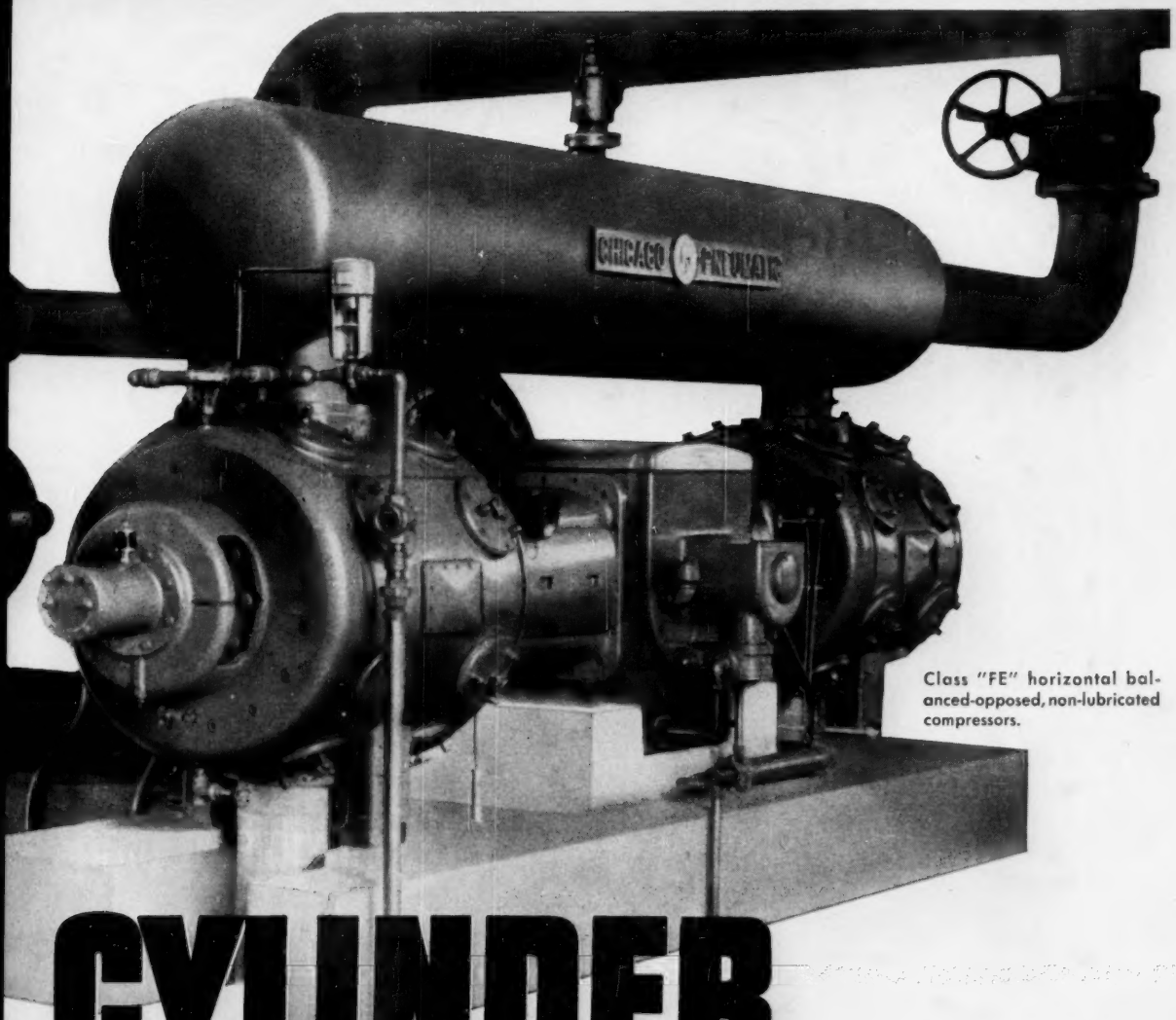
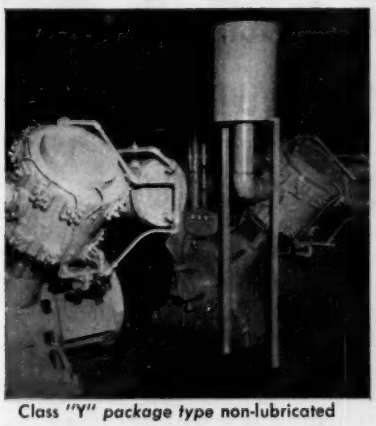
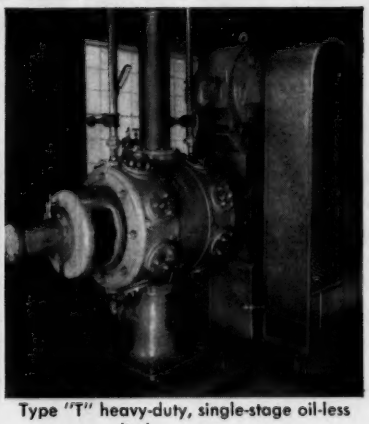


Class "FE" horizontal balanced-opposed, non-lubricated compressors.

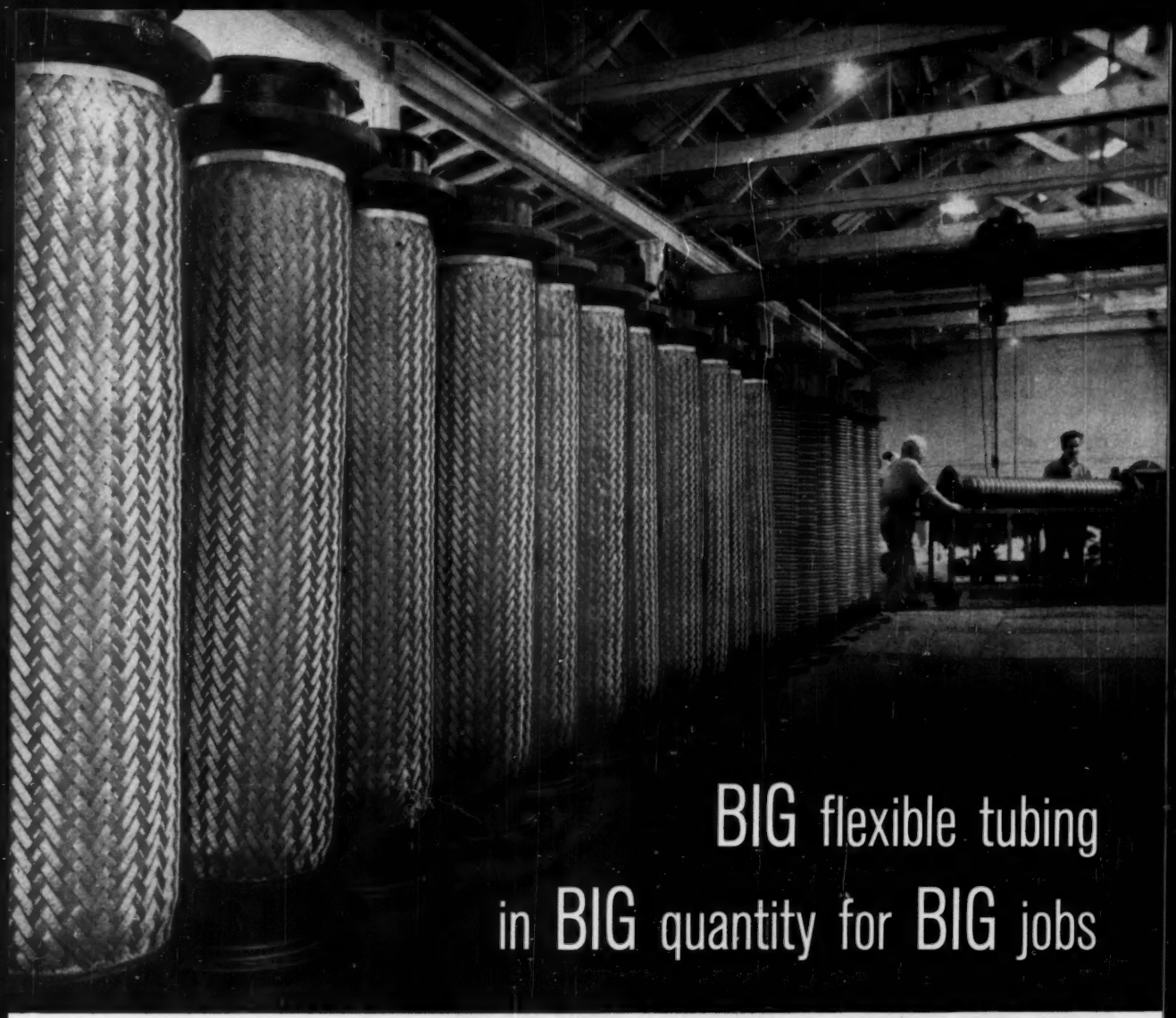
CYLINDER



Class "Y" *package type* non-lubricated compressors.



Type "T" heavy-duty, single-stage oil-less cylinder compressor.



Whatever your flexible metal tubing problem, Anaconda's broad design and manufacturing capability can make your job easier

The big corrugated stainless steel tubing assemblies shown above were designed and manufactured by Anaconda Metal Hose for water lines in the missile program. Construction of these 12″ I.D. lines is corrugated stainless steel flexible tubing, reinforced with stainless steel wire braiding; end fittings are floating flanges. This type of tubing can also be produced in other metals as Bronze, Steel, in standard ID's through 16″ and standard lengths of 20 feet.

Small flexible tubing for small tough jobs, too. At the other end of the scale are tiny ⅛″ Vibration Eliminators. And in between, the variety of flexible hose assemblies – in size, material, and design – is almost infinite.

Sales Engineering Consulting Services that follow through from original design to finished product. Simply let us know your needs, with conditions, dimensions, and such sketches and drawings as might be necessary to give us an understanding of your problems. We will work out design problems with your engineers and draftsmen. We will manufacture the flexible connectors. And we will make specialists available for immediate service calls on equipment or field installations. These services are available through our representatives in leading cities—see listing "Hose-Metal" in the Yellow Pages. Or write: Anaconda Metal Hose, Box 791, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

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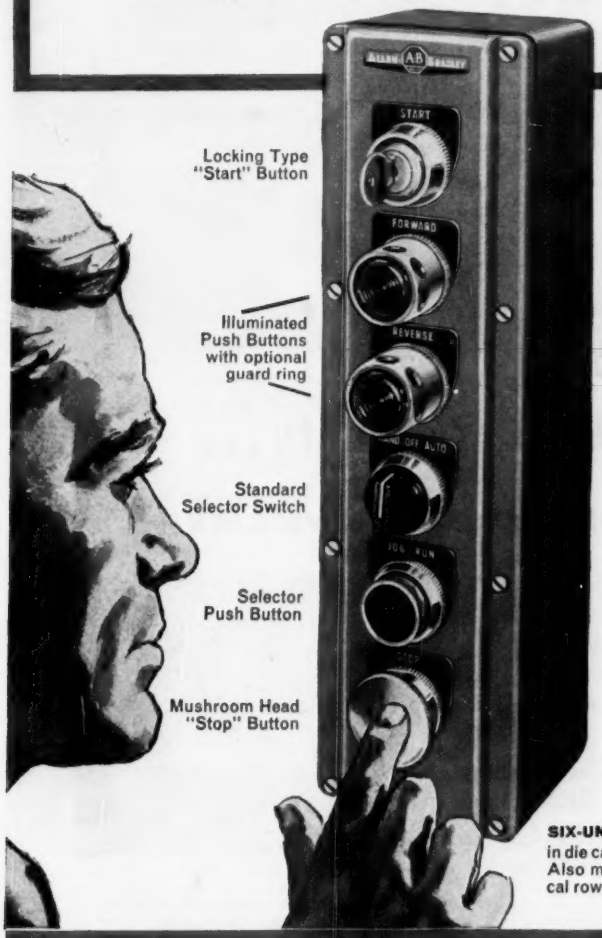
Metal Hose

BE SURE YOU GET

Quality Appearance Quality Operation

Specify Allen-Bradley's line of ***OILTIGHT CONTROL STATIONS***

Allen-Bradley oiltight units and stations harmonize with the trim lines of modern machine tools —they look as if they were a part of the machine. Also, from the wide selection of control units, you'll be able to satisfy every operating requirement. A-B control units are positively oiltight—impossible for oils and cutting fluids to foul the contacts. And the silver contacts assure reliable operation. The rugged construction and generous wiring room of all A-B stations are valued by the installation engineer. Insist on Allen-Bradley pilot control units and stations—you can't make a mistake! Send for Publication 6090.



Locking Type "Start" Button

Illuminated Push Buttons with optional guard ring

Standard Selector Switch

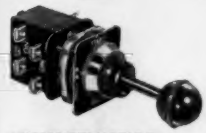
Selector Push Button

Mushroom Head "Stop" Button

FLUSH HEAD
push button, also made with extended head.

WING LEVER PUSH BUTTON
Combines push button and selector switch.

PUSH-TO-TEST PILOT LIGHT
Six different color lenses available.

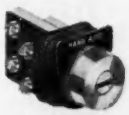


4-WAY SELECTOR SWITCH
Also furnished for 2-way operation.

PILOT LIGHT
Transformer or full voltage types.

DOUBLE CIRCUIT
Has 2 N.O. or 2 N.C. sets of contacts.

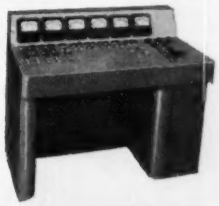
PILOT LIGHT CLUSTER
Four lights of different colors in one unit.



SELECTOR SWITCH
With coin slot operator. Other operators available.

CONVENIENCE RECEPTACLE
For plugging in work light or small tools.

SPECIAL CONTROL CONSOLES
can be furnished to meet your exact operating requirements.



SIX-UNIT CONTROL STATION
in die cast aluminum housing. Also made with up to 4 vertical rows with 4 units per row.

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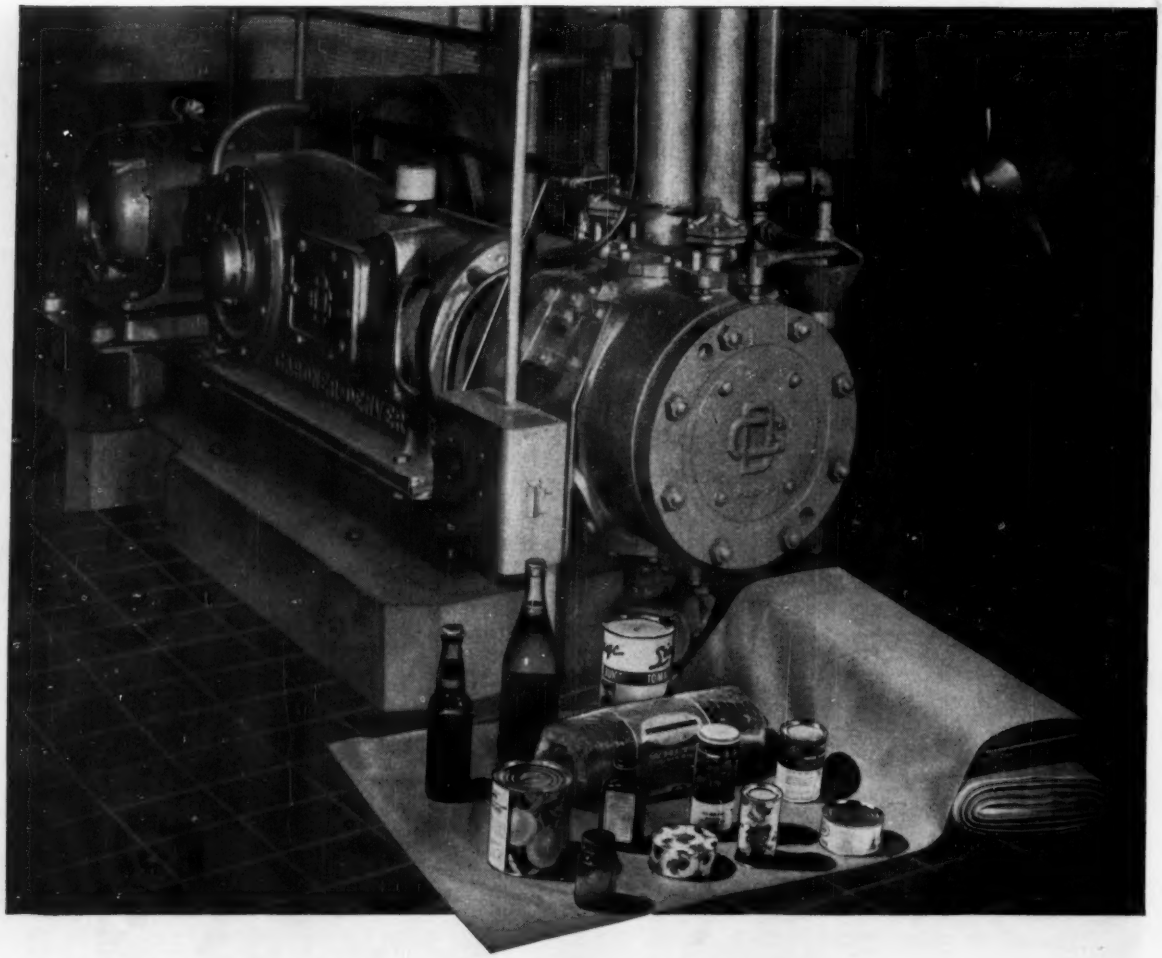
Allen-Bradley Co., 1337 S. First St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ontario

QUALITY MOTOR CONTROL

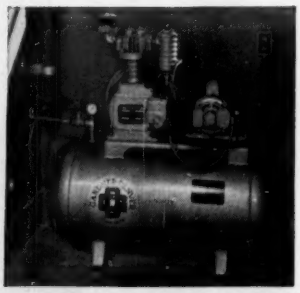


Air helped produce these products . . .

pure, oil-free air from GARDNER-DENVER

This Gardner-Denver Model CRX has enabled many an industry to utilize low-cost compressed air power without penalty to their products. The CRX produces pure, oil-free air without special filters. It provides versatile "go" power to help speed production, cut costs, and keep air-actuated equipment moving.

If a trace of oil in your air line is *too much*, ask your Gardner-Denver Compressor Specialist about the CRX. Sizes range from 100 to 1400 cfm.



For a small, oil-free compressor, the Model CACB is hard to beat. Supplies 4 to 5 cfm . . . discharge pressures 40 to 100 psi.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario

New B&W REFRACTORIES FOR THE CHEMICAL INDUSTRY

B&W's line of refractories has been enlarged by the addition of new heavy duty firebrick and new ramming mixes. These new products, now offered after many years of developmental and field experience, are specifically designed for superior service in gas generators, industrial carbon baking furnaces, silicate of soda tanks and sulphur burners and other typical furnaces commonly used in chemical processing.

FIREBRICK

★

KAO-HB

HIGH BURNED SUPER DUTY FIREBRICK

Fusion point 3220 F. This brick offers an excellent balance of properties to assure superior service. It provides approximately 5% more alumina content and lower total impurities than competitive brick. It has excellent spalling resistance.

KAO 60

60% ALUMINA FIREBRICK

Fusion point 3250 F. Provides higher hot load strength than any competitive brick. Spalling loss is only 1%.

KAO 70

70% ALUMINA FIREBRICK

Very low total impurities provide long life. Spall loss of only 2%.

RAMMING MIXES

★

MULRAM E

USE LIMIT 3200F
ALUMINA CONTENT—80%

This new ramming mix with extremely low permeability provides exceptional resistance to slag or molten metal penetration. High strength provides good erosion resistance.

MULRAM EF

USE LIMIT 3100F
ALUMINA CONTENT—80%

Similar to Mulram E but supplied in finer grain.

FOR COMPLETE PROPERTIES SHEETS and additional information on these new B&W Refractories products, write to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N Y.

B&W

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

R-6578

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

Why Hunter Packing Company uses STANOIL Industrial Oil

Two reasons: (1) STANOIL is a superior oil. (2) Along with STANOIL, Hunter Packing receives experienced lubrication technical service.

A special antioxidant in STANOIL gives the oil resistance to *chemical* change. Deposits are minimized. The oil has a high viscosity index, is resistant to *temperature* change. It lubricates effectively at both high and low temperatures. Due to special refining techniques, STANOIL will not readily emulsify. A special additive minimizes foaming. STANOIL has a low pour point. It flows freely at low temperatures. A rust inhibitor in STANOIL "plates out" on metal surfaces.

W. P. "Sandy" Wehking, the Standard Oil man who calls on Hunter Packing Company, has plenty of experience in technical service work. He's been at it for 17 years. Sandy studied chemistry at Blackburn College. He has also completed the Standard Oil Sales Engineering School.

To get more information about STANOIL Industrial Oil and to obtain technical help on your lubrication problems, call the Standard Oil office near you in any of the 15 Midwest or Rocky Mountain states. Or write, **Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.**

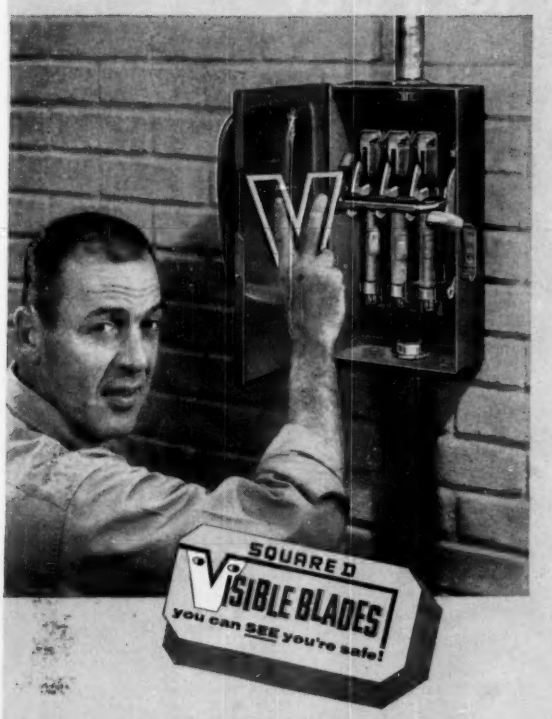
Quick facts about **STANOIL Industrial Oil**

- Antioxidant gives oil resistance to chemical change, minimizes deposits.
- Inhibitor "plates out" on metal surfaces, prevents corrosion.
- Receives special refining to eliminate emulsion problems. Contains additive to minimize foaming.
- High viscosity index. Resists temperature change.

You expect more from **STANDARD** *and you get it!*

Temperature check. Frank Persson of Hunter Packing Company and Standard Oil lubrication specialist W. P. "Sandy" Wehking inspect one of four compressors in Hunter plant that uses STANOIL Industrial Oil.

FOR SAFETY YOU CAN SEE REMEMBER THE "V" FOR VISIBLE BLADES!



• The men who pull the switches will tell you what can happen when a switch, *believed* to be open —*isn't*. A lot of things can happen—and every one of them is bad. Personnel safety is in jeopardy. Motors can single-phase. Machinery and work can be damaged. Down-time can skyrocket.

Doesn't it make sense to insist on **V**isible **B**lade construction which gives you a road block against any of those possibilities? Doesn't it make equally good sense to insist on the safety switch which gives you that construction—plus a lot of other performance advantages? Evidently it does, because *Square D switches have never been out of first place in more than 50 years!*

They cost no more... why settle for less?

MAIL the coupon for latest Safety Switch Bulletin

Square D Company, Dept. SA-125
1601 Mercer Road, Lexington, Kentucky

Please send me your latest SAFETY SWITCH BULLETIN

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CITY_____ ZONE____ STATE_____

SQUARE D COMPANY

wherever electricity is distributed and controlled

Marlo liquid/gas heat exchangers

are Manufactured to Your Exact Requirements

These quality-constructed units can be supplied in any alloy, any size, for any application.

SPECIFICATIONS ON THIS UNIT

Application: solvent recovery
Surface ratio: 19 to 1
Material:
- **Casing:** Stainless steel 304, 3/16" thick
- **Coil frame:** Everdur, 0.129" thick
- **Fins:** Copper, 0.012" thick
- **Tubing:** Copper, 5/8" O.D., 0.049" wall

Test pressure — coil: 500 psig
Test pressure — casing: 30 psig

GENERAL DESCRIPTION:

Overall dimensions: 94" x 31" x 52"
Weight: 3400 lb.
Tube spacing: 1½" staggered centers
Fin spacing: 8 per inch
Face area: 20.9 sq. ft.
Inside surface: 202 sq. ft.
Outside surface: 3810 sq. ft.

Write or phone for additional information for your application.

MARLO coil co.

ST. LOUIS 11, MISSOURI

Quality Air Conditioning and Heat Transfer Equipment Since 1925

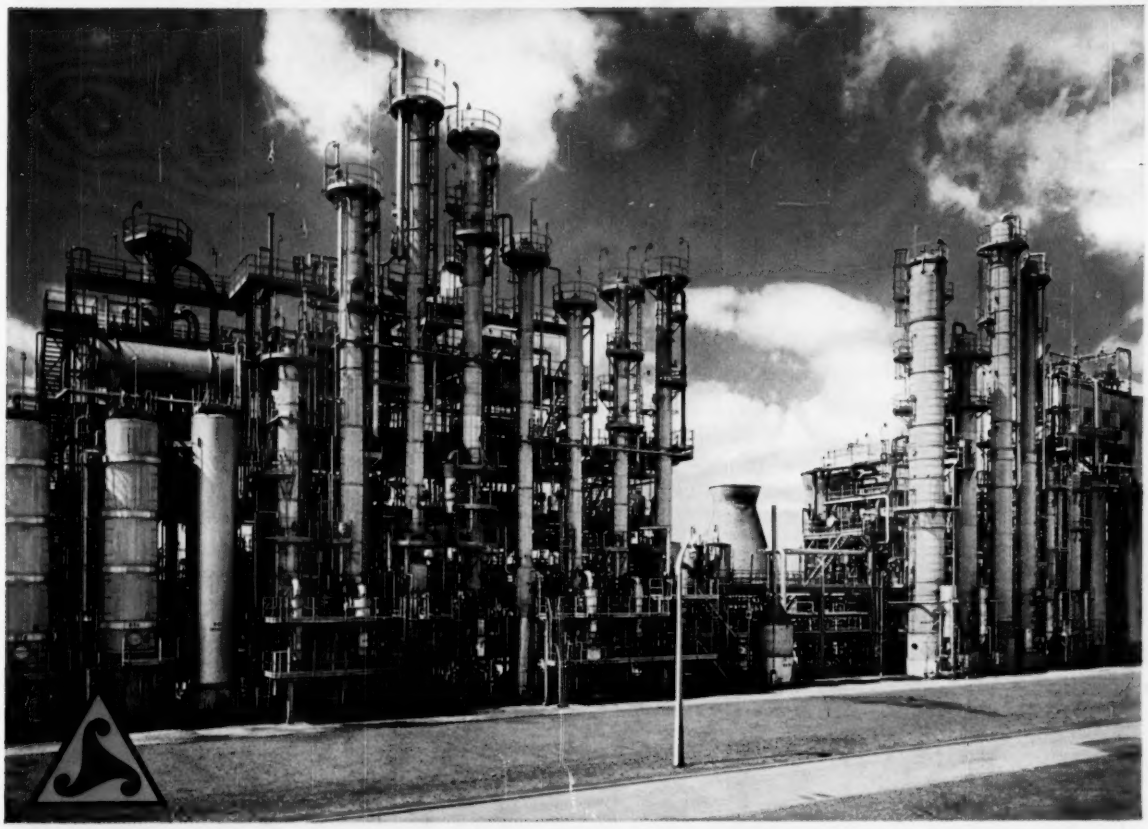
BRITISH PREMIERE

STONE & WEBSTER ENGINEERS
BRITAIN'S FIRST CUMENE-PHENOL PLANT

British Hydrocarbon Chemicals Limited's Cumene-Phenol Plant, the first in Britain, was recently completed by Stone & Webster Engineering Corporation, a pioneer in the design and construction of phenol plants in both the United States and Japan.

The new installation is the tenth project designed and constructed by Stone & Webster for BHC at Grangemouth since 1950. The Cumene Unit employs the process of Scientific Design Company Inc. while the Phenol Unit utilizes that developed by The Distillers Company Limited.

Stone & Webster's unequalled experience and engineering skill in the process field can be of profit to you on your next project. Write or call our nearest office.



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What is most important to you?

- ☐ packingless
- ☐ self-priming
- ☐ it's a LaBour

PACKINGLESS: No stuffing box troubles because there's no stuffing box—no leaks, no wear, no repacking. Saves time and money.

SELF-PRIMING: Avoids bottom outlets in tanks, permits great flexibility of piping layout, keeps dangerous liquids under less than atmospheric pressure during transfer to pump—features worth a great deal to you.

IT'S A LaBOUR: Corrosion-resistant characteristics are assured because LaBour operates its own foundries, holding extremely close metallurgical tolerances. Efficiency and dependability are proved by LaBour's nearly 40 years of service to the chemical industry, dating back to the first self-priming centrifugal pump ever put on the market.

YOU GET ALL THREE FACTORS WHEN YOU SPECIFY LaBOUR TYPE G

ORIGINAL MANUFACTURERS OF THE SELF PRIMING CENTRIFUGAL PUMP

LABOUR

THE LaBOUR COMPANY, INC. • ELKHART, INDIANA
WHITE PIGEON, MICH. • LONDON, ENGLAND

My name's Nosey. I'm the Esso Solvents Expert. And I'm illustrating the fact that Varsol's odor is *down* and its quality *up*.

As you know, odor is hard to control without sacrificing solvent power. That's why Esso has been researching low odor for years. Fact is, we have an Odor Panel composed of experts in all of our refinery and research establishments. These people are dedicated to the continuing improvement of "low odor" Esso Solvents.

Constant research makes it possible to deliver our solvents fresh and uncontaminated from modern, conveniently located terminals. For further information, contact your nearest Esso office or write: Esso Standard, Division of Humble Oil & Refining Company, 15 West 51st Street, New York 19, N. Y. And tell 'em Nosey sent you!

ESSO

VARSOL®

In Industry after Industry..."ESSO RESEARCH works wonders with oil"

Isostripper at left, tallest column in new unit, splits saturated-C_4 reactant stream and also separates alkylate product.

Alkylation Unit Yields Dual Benefit

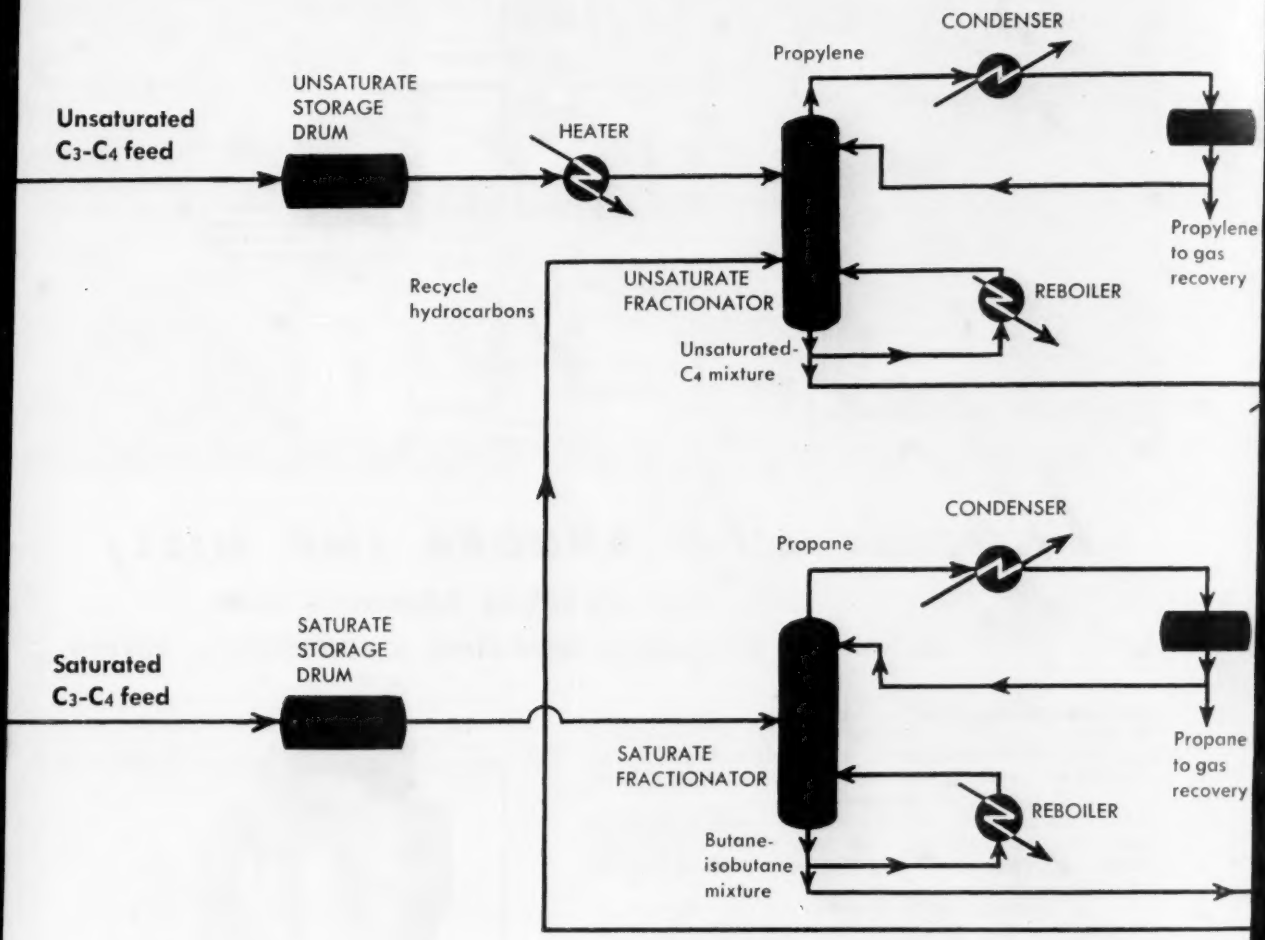
New HF-alkylation plant of British American Oil Co. solves problem of surplus butanes by reacting isobutane, olefinic C_4's to make high-road-octane component for gasoline blending.

N. P. CHOPEY *Assistant Editor*

A new, 2,900-bbl./day alkylation unit, started up this summer, is solving two problems at once for British American Oil Co. at the firm's refinery at Clarkson, Ont. In reacting butylenes with isobutane to produce iso-octane, the facility not only helps BA boost road octane of motor gasolines but also provides an attractive outlet for surplus butanes within the refinery.

The new alkylation plant uses hydrofluoric acid as catalyst. In its design, provision has been made to expand capacity to 6,000 bbl./day and also to alkylate propylene as well as butylenes.

Unfold Flowsheet ➡



► **Two Problems, One Solution**—BA was faced with the problem of finding economic use at Clarkson for excess butanes, which couldn't go into finished gasolines because of vapor-pressure limitations. Problem was especially acute during the summer, and in summer months the refinery used up large amounts of butane by burning it as plant fuel.

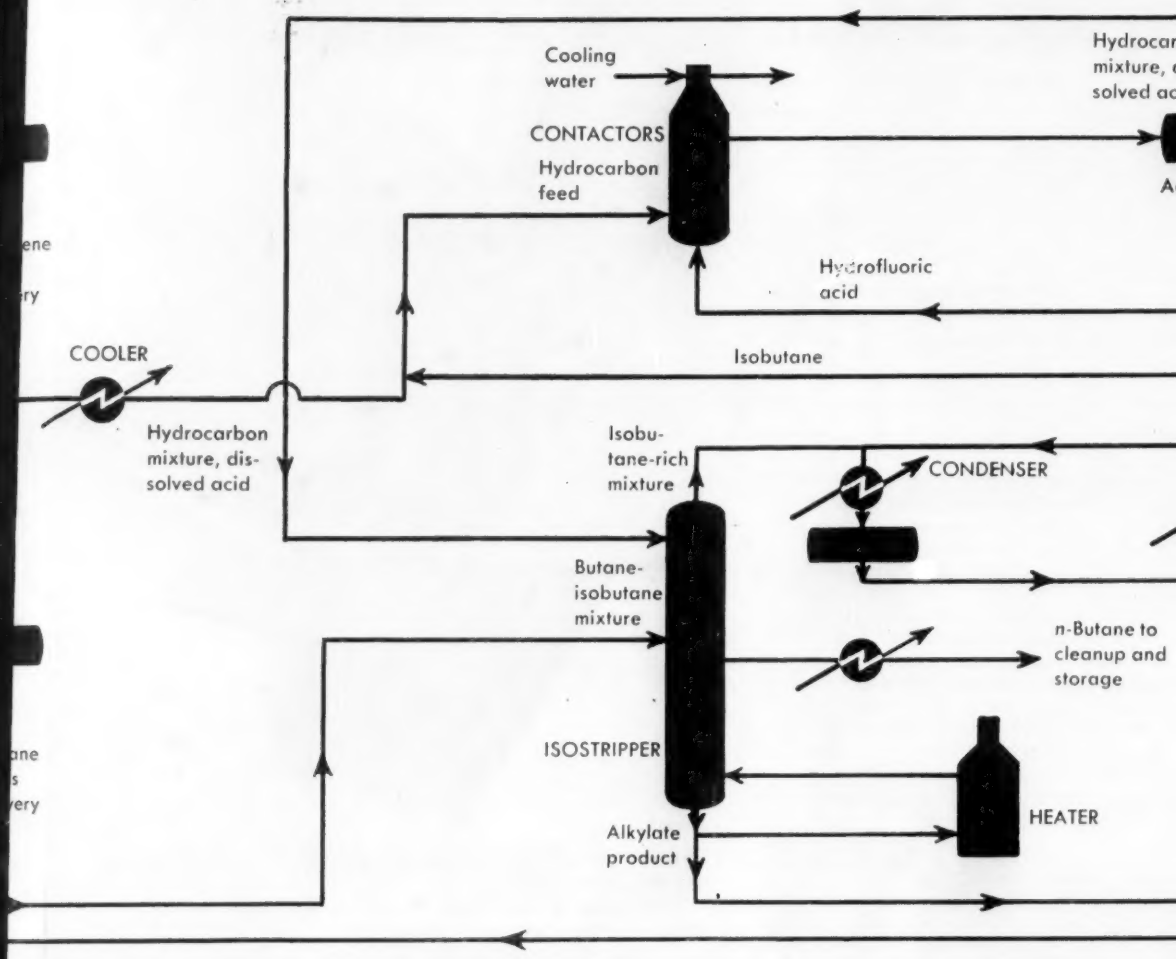
At the same time, demand was building up for increased road octanes in gasoline for motor fuel use. Road octane measures the actual power a gasoline will deliver in an automobile engine under road conditions. It can be improved by lowering the gasoline's sensitivity—the numerical difference between research and motor octanes.

Alkylation was the solution for both these situations. BA's alkylate product is not only a good outlet for butanes but also an excellent blending component to improve road octane. By itself, it has a very low sensitivity; when treated with tetraethyl lead, sensitivity can become negative.

► **Why Hydrofluoric**—A thorough economic study was made of the refinery situation at Clarkson, to determine whether BA should use sulfuric or hydrofluoric acid as catalyst. The result: HF alkylation won the nod, because it would yield both capital- and operating-cost advantages based on alkylation of butylenes, and even greater advantages if the refinery went to propylene alkylation, as well, in the future.

One process feature of HF alkylation is that the acid can be regenerated. Another is that although alkylation with sulfuric acid catalyst requires low temperatures—around 40-50 F.—to minimize or avoid side reactions, HF alkylation can be carried out at temperatures as high as 100 F. or greater. All other things being equal, however, lower temperatures for HF alkylation will yield higher octane ratings for the product.

Location of the Clarkson refinery provides an attractive cooling situation. Cooling water comes



from Lake Ontario, and most of the year its temperature doesn't go above 50 F. Therefore, it wasn't necessary to include refrigeration equipment in design of the new unit.

▶ **A Look at the Plant**—BA's new unit uses Universal Oil Products Co.'s alkylation process, and the unit was designed by UOP. Detailed engineering was by Procon Canada Ltd., Toronto, Ont.

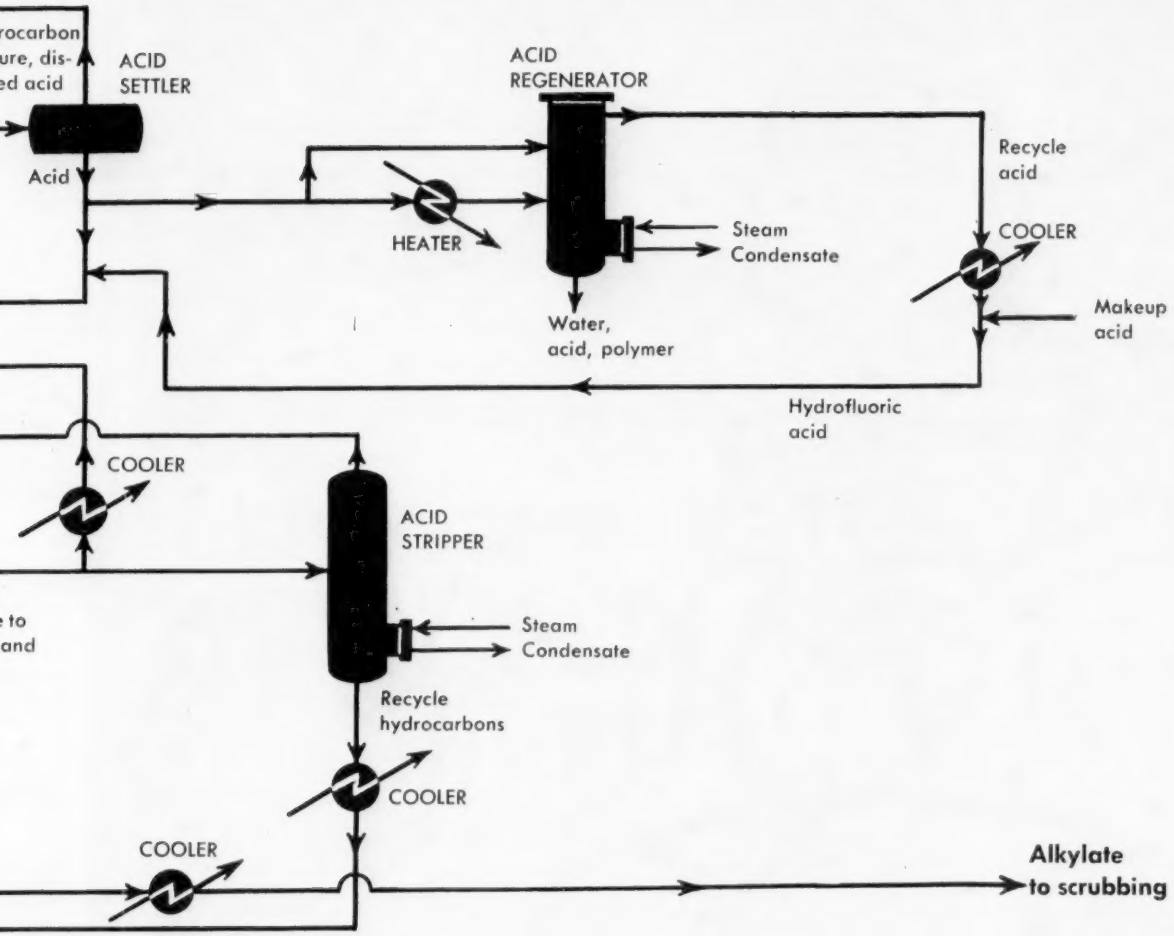
The facility treats saturated C_3-C_4 feed from crude distillation and catalytic reforming, olefinic C_3-C_4 stock from catalytic cracking. Former stream is pretreated in a diethanolamine tower that removes H_2S; the olefin stream undergoes both caustic scrubbing and diethanolamine treatment before going to alkylation.

Heart of the process is a pair of shell-and-tube contactors where the alkylation reaction takes place. An unusual feature is that they are not agitated mechanically; instead, the hydrocarbons and the acid are combined by jet mixing.

▶ **Feed Streams**—First phase of the alkylation operation is to prepare the hydrocarbon feed streams for the contacting step. The saturated and olefinic mixtures are initially stored in 2,000-bbl. pressure vessels to allow settling time for water removal. From these drums the two mixtures go respectively to saturate and unsaturate fractionators, where C_3's are removed overhead. Current feed rates are 2,800 bbl./day to the saturate tower, 5,200 bbl./day to the unsaturate tower.

Propane removed by the saturate fractionator is sent to catalytic cracker gas recovery operations; the unsaturated C_3 stream goes to either LPG storage or a polymerization unit for conversion to poly gasoline.

Unsaturate bottoms stream, containing butylenes plus some normal butane and isobutane, is cooled and then goes directly to the contactors. Bottoms from the saturate fractionator go to a tall isostripper column, where normal butane



comes off as a sidestream and isobutane leaves overhead. Latter stream goes to the contactors.

► **Contact and Settle**—The butylene and isobutane streams are combined and fed to the contactors, where they are mixed with hydrofluoric acid. Reaction temperature is kept as low as possible by maintaining a large flow of cooling water.

Contactor effluent goes to an acid settler, where the reacted hydrocarbon mixture plus dissolved acid are withdrawn overhead. This stream goes to the isostripper for separation of the alkylate product as bottoms. Product is cooled, then sent to a scrubber to neutralize any last traces of acid that may be present. (Under normal conditions, however, the stream is acid-free when it leaves the isostripper.)

F-1 (or research) octane of the alkylate is 95 clear, 105 with addition of 3 cc. tetraethyl lead per U. S. gallon. Reid vapor pressure is 6 psi., final boiling point is 360 F.

► **Recycle Streams**—The acid separated in the settler recycles to the contactors. To control acid strength and water content of the system, part of this stream is diverted to a distillation column where the acid is regenerated and leaves overhead. Regenerator bottoms consist of a constant-boiling mixture of acid and water, plus polymerized hydrocarbons; these bottoms are drained off intermittently.

Acid consumption is about 0.2-0.3 lb. per barrel of alkylate produced. Makeup acid is added in anhydrous form.

Isobutane recycle rate is kept around 24,000 bbl./day and purity of the isobutane stream is maintained around 95%. Part of the stream is sent through an acid stripper to control propane content; HF leaves overhead and is recombined with the isostripper overhead stream, and hydrocarbon bottoms from the acid stripper are recycled to the unsaturate fractionator.

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WELDING FITTINGS

MADE BY MEN WHO KNOW TUBING

B&W Welding Fittings manufacturing is integrated with the Division's own tube-making and steel-making facilities. Consider the relation between tube-making and the manufacture of welding fittings . . . in addition to knowing welding fittings manufacturing, B&W knows of the making of tubing from which fittings are produced. This knowledge plus integration of facilities permits B&W to provide superior fittings, completely quality-controlled, matched to end-use service. It also means on-time deliveries of fittings made from tubing of the specialized steels because B&W can closely control manufacturing schedules from melt to the shipment of the finished product.

B&W Welding Fittings and Flanges are available through qualified distributors in carbon steel and the B&W CROLOYS in a complete range of types and sizes. Write for B&W Bulletin FB502. The Babcock & Wilcox Company, Tubular Products Division, Welding Fittings Plant, P. O. Box 230, Beaver Falls, Pennsylvania.

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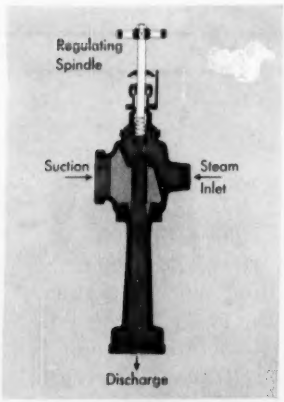
Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

ON THE WAY... SAME DAY

The ejector illustrated in photo and drawing is one variety of SK Steam Jet Exhauster—an air and gas pump which operates on the jet principle using plant steam. As indicated, these units are standard, general-purpose units economically suitable for applications such as pump priming, exhausting, evacuating, cleaning, transporting, compressing, agitating, and general vacuum service. Jet Exhausters are made and stocked in cast iron, stainless steel, Haveg, hard lead, PYREX brand tubing, and impervious graphite in popular sizes, see Data Sheet J-2. They can also be made in bronze, Monel, Everdur, and other machinable materials. In addition to these units, SK also makes a complete line of Steam Jet Vacuum Pumps for providing a range of suction pressures from atmosphere to 25 microns Hg abs. Refer to Bulletins 5E, 5H2, and 5H3 for information on these.



This jet ejector is being shipped from SK stock on the same day the order arrived.

This is *one* of *three* vital reasons why it pays to buy jet apparatus from SK. The others . . .

. . . one, SK pioneered the jet ejector in 1876 and, since then, has accumulated a wealth of valuable data on jet ejector application and performance. Everything we've learned is available to customers.

. . . two, SK has "special material" jet ejector designs unequalled by any other manufacturer. Many are carried in stock. Thus, customers can choose the best material for the job.

Recently, SK published a data sheet on ejector types, special stock materials, and sizes stocked. It's a valuable addition to any engineer's "source file." Get a copy merely by requesting "Data Sheet J-2."

For immediate delivery, standard SK Jet Ejectors, Rotameters, and Flow Indicators are stocked in Cornwells Heights (Phila.), Pa., Houston, Texas, and San Francisco, Calif.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
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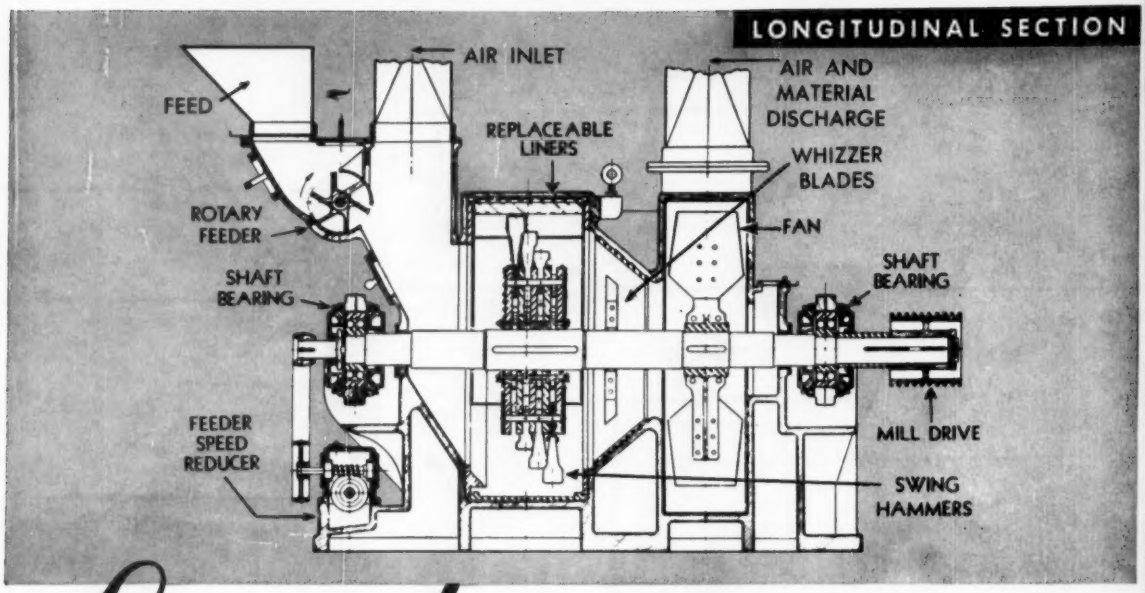


Raymond's RUGGED IMP MILL

THE MULTI-PURPOSE GRINDING UNIT

GRINDING • BLENDING • SEPARATING • CONVEYING • DRYING

✕ DESIGNED FOR FINE GRINDING

The Imp Mill is particularly intended for medium fine and fine grinding of softer non-metallic minerals and many manufactured products. Wide usage of the Imp Mill is made in a great many fields where pulverizing is desired.

✕ VERSATILITY OF APPLICATION

Mills are built in a variety of types and sizes to produce many different capacity requirements. They have a wide degree of adjustment of product fineness, ranging from about 20 mesh to 325 mesh, depending upon material handled.

✕ NEED OF CLASSIFIER

For higher finenesses or more uniform finished products than the Imp Mill would normally produce, an air classifier may be used. Either an integral Whizzer Separator or a Raymond Mechanical Air Separator could be installed according to the particular type of operation needed and the material to be processed.

✕ FLASH DRYING

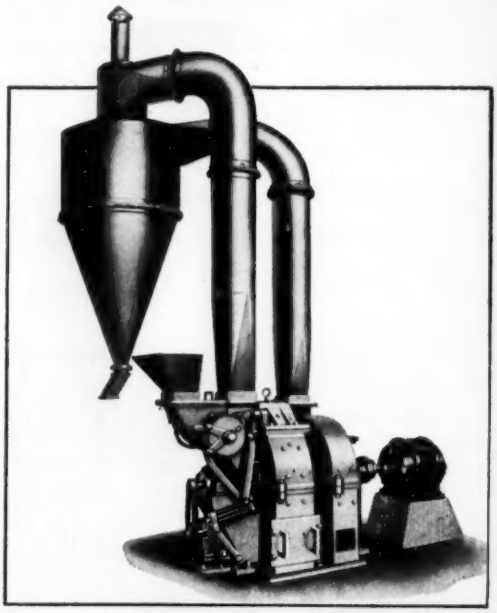
The basic design of the Imp Mill readily adapts itself to the simultaneous drying and pulverizing of materials. The Mill utilizes heated air or products of combustion for removing surface moisture and, in special cases, chemically combined water from materials during grinding. In all instances air is used as the conveying medium.

✕ FLEXIBLE IN INSTALLATION

Each Mill System is a compact installation, engineered to fit most any plan or layout. The floor space is held to minimum requirements of Mill and Drive Motor. Piping variations permit cyclone collector, within limits, to discharge material where needed. Systems are completely enclosed from feed hopper to finish bin.

✕ DUSTLESS OPERATION

The excess air is diverted to a secondary collector or, where permissible, can be exhausted to the atmosphere.



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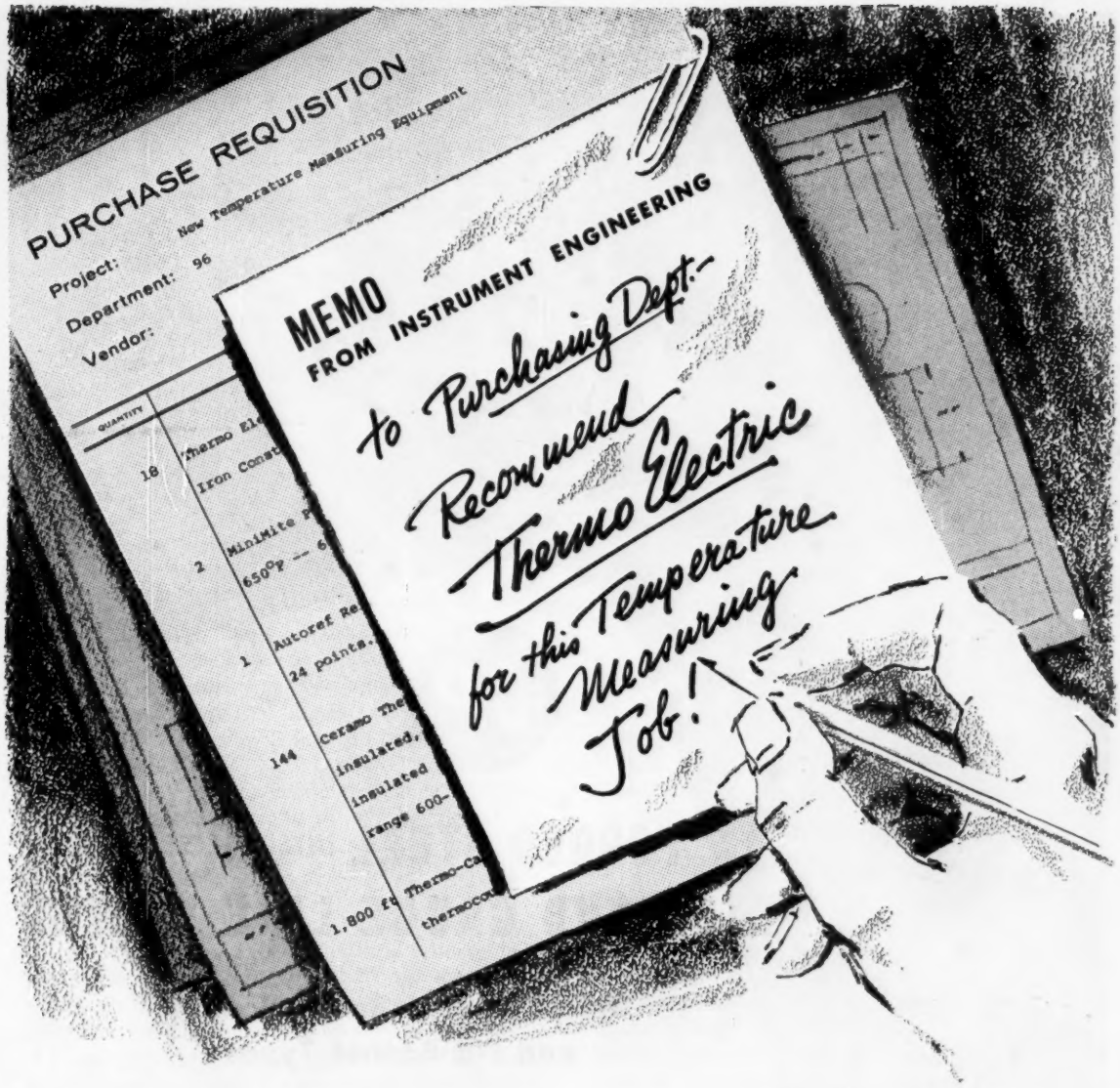

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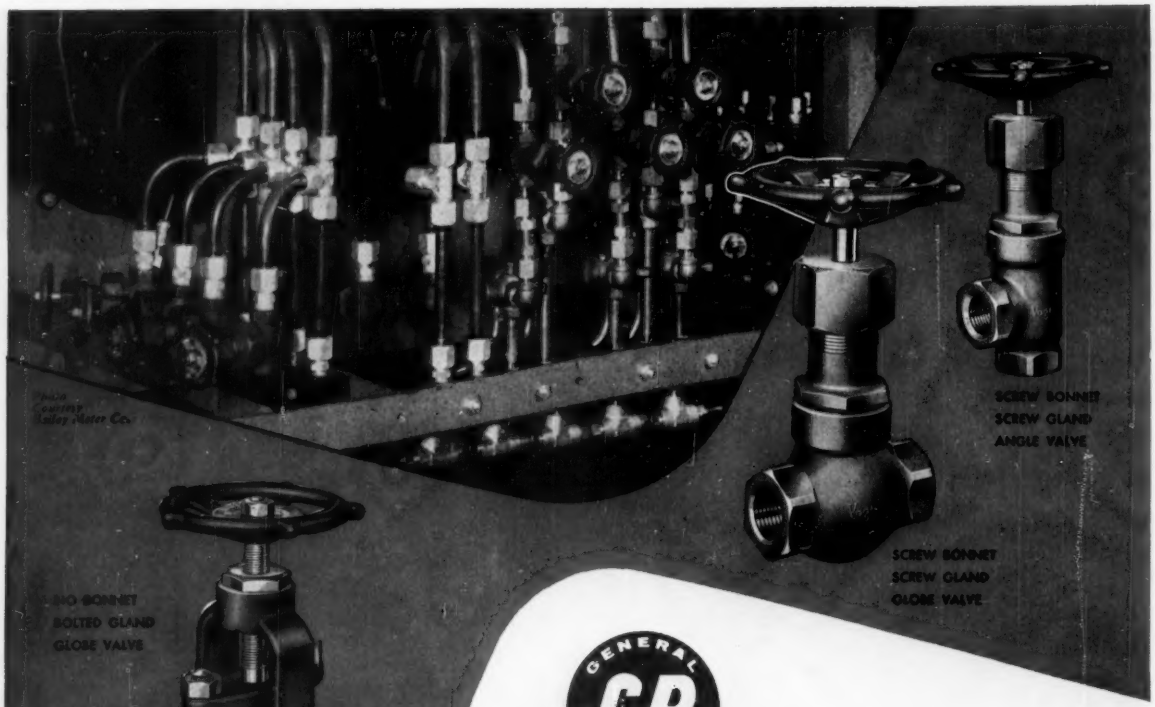

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The New Chemical Engineering

Chemical engineering, whether we consider the new or the old, is essentially a synthesis of chemistry, physics and mathematics, tempered with a concern for the dollar sign and applied in the service of mankind. During the 50 and more years that the profession has been recognized in the U. S. as a separate branch of engineering, man's needs have changed tremendously and so has chemical engineering.

Thus it is that today our changing profession faces a challenge and an opportunity to put to better use the advances that are being made in its basic sciences and in their application.

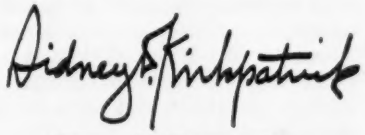
Nowadays, we hear more and more about "chemical engineering science" and the "chemical engineering scientists." These terms certainly imply an inconsistency if interpreted too literally as "the science of applying other sciences." However, they take on real significance when we recognize them as a trend toward better understanding and closer working relations with the physical sciences from which our profession sprang.

We all recall how, almost 20 years ago, chemical engineers were called to take a leading role in the atomic energy project. Why was this? Primarily because, on the one hand, they were better grounded than other engineers in chemistry and physics. On the other hand, they had more experience and perhaps more resourcefulness in translating pure mathematical theory into production processes. These same qualifications today are leading many chemical engineers into exciting jobs in missiles and their fuels, into the space race, into automation and systems engineering, into cryogenics and high temperature technology. And chemical engineers have invaded the new "chemical metallurgy," solid-state chemistry and physics.

But the interesting thing about all this is that "the new chemical engineering" is not really new but represents a re-emphasis of the fundamentals of the chemistry, mathematics and physics from which we have always drawn our strength.

Where else, then, can we better renew our faith in these fundamentals and refurbish our vision and resourcefulness than in the atmosphere of organized research? Today the largest proportion of our new chemical engineering graduates goes into research and development. So, it has seemed eminently appropriate to the editors of this magazine to join with Midwest Research Institute in a venture which, for the magazine, is a complete departure from past activity—the sponsorship, with MRI, of a two-day technical conference, held in the latter's home territory.

This conference, signalizing The New Chemical Engineering, was held in Kansas City's Hotel Muehlebach on November 29 and 30. Of the 10 papers, two appear in this issue while the remaining eight will be printed in the next three issues. Divided into three groups, under the headings of The New Chemistry, The New Mathematics and The New Tools of Engineering, these papers deal with coming changes and with new ways of looking at and applying the underlying sciences in the service of chemical engineering.



SIDNEY D. KIRKPATRICK

SIDNEY D. KIRKPATRICK, *who retired in* 1959 *as Editorial Director of* CHEMICAL ENGINEERING *and* CHEMICAL WEEK, *was the keynote speaker at the first of what we hope will be an annually recurring series of technical conferences co-sponsored by this magazine. Mr. Kirkpatrick is still a consulting editor of the McGraw-Hill Book Co., and one of three co-editors of the forthcoming fourth edition of Perry's "Chemical Engineers' Handbook."*

How Statistics Apply to Chemical Processes

Awareness and application of the new techniques in statistical and mathematical methods can produce significant economic advantages.

T. L. KOEHLER, *American Cyanamid Co.*

To describe the development and present status of statistics as applied to the processing aspects of the chemical industry, I shall emphasize those techniques that have been found to be of value in the areas commonly called development and process improvement.

Among the many statistical techniques of value to the engineer, there appears to be one criterion that separates them into two major groups. First, we have those techniques that are largely based on a logical system of deductive reasoning and, secondly, those techniques based on inductive reasoning. Generally, those techniques whose basis is deductive reasoning are classified as statistical quality control methods, and those based on inductive reasoning are commonly called design of experiments.

Let me warn the reader that while these designations are applicable from the standpoint of discussing techniques, they are not necessarily applicable in describing the function or range of interest of formally organized industrial groups. For example, many quality control groups in the chemical industry concern themselves with all applications of industrial statistics.

Let us first consider the general area of statistical quality control. I think it is of interest to review briefly its history. In 1931, following his experience in manufacturing during World War I, Dr. Walter A. Shewhart[15] of the Bell Telephone Co. wrote a book entitled "Economic Control of Quality of Manufactured Product." As the title indicates, he was primarily concerned with the application of statistical methods to the function of quality control of product. He was concerned with this topic because the advent of mass production had left a serious void in the methods used to obtain the objective of good manufactured material.

Prior to mass production, each worker was his own inspector. With mass production, it was no longer possible for the worker to inspect his own material and, as a consequence, mass production that got its first real test during World War I seemed to be simply a way to produce more but shoddier goods.

Shewhart's book concerned itself with two aspects of quality control. First, there is the general area of finished product inspection, in which large lots of material could be inspected by examination of small samples. From this, a second area of quality control known as in-process control logically follows. The major tool, here, was the statistical quality control chart.

The book caused relatively little interest until the advent of World War II, when the government inserted into its contracts for war material the provision that all submitted material would be subject to inspection by a sampling plan. To insure that their contracts would not be canceled, virtually all manufacturers of war materiel also began to use sampling plans. As they watched their own inspectors rejecting material, it was only natural that they should very quickly adopt an inspection procedure applicable at various places in the process, in order to reject or correct defective material as soon after it was produced as possible. Thus, by the end of World War II, the application of sampling plans and control charts in many segments of industry was accepted as standard.

Even during World War II, however, the acceptance of quality control in various industries was directly related to the number of individual items produced. This made the application of standard sampling plan and control chart technique a way of life in the fabrication industry, but had very little effect on the producers of bulk chemicals. Fortunately, several small but significant changes in our approach in recent years have measurably increased the value of statistical quality control techniques to the chemical industry both as a management and an engineering tool.

Examine Reasons for Control Chart

Before considering the details of the control chart itself, it is important to decide what reasoning lies behind its use. The following sequence describes the process of deductive reasoning:

1. Collect data from a process apparently operating in a normal fashion.
2. By some analysis, select those data points that seem to refute the hypothesis of normal operation.
3. Attempt to assign a cause to the abnormal data.

The control chart is of particular use in Stage 2; that is, in the detection of an improbable test result, which in turn implies abnormal material.

In order to detect improbable process performance, we must first of all choose some point in the process on which a yield or quality measurement is available. Usually, we would then allow data to accumulate, and plot averages and ranges of sets of four observations.

After a reasonable number of averages and ranges have been plotted, 99% control limits can be placed on the charts. These control limits imply that from chance alone only one average or range in 100 will fall outside the control limits.

If, on future performance, a larger frequency of points is found outside the control limits, there is an indication of abnormal performance. Additional criteria may be used to judge abnormal operation. For example, the occurrence of a larger number of points on one side of the average may lead us to believe that the process is undergoing an abnormal shift in operation.

When unusual behavior of some kind is detected from the chart, it is then the job of the engineer to associate this abnormal performance with a process characteristic. The specific cause is seldom obvious. Hopefully, however, the detection of abnormal process behavior will help the engineer in the formulation of several hypotheses regarding the cause of the abnormal behavior. In this case, the control chart may be the instrument that will institute an experimental program designed to check out the various hypotheses.

Since the conception of the control chart by W. A. Shewhart, most of the modifications were made to simplify the charts. These simplifications were aimed at either reduction of the amount of arithmetic necessary to keep them, or simplification in the interpretation or signaling mechanism of the charts.

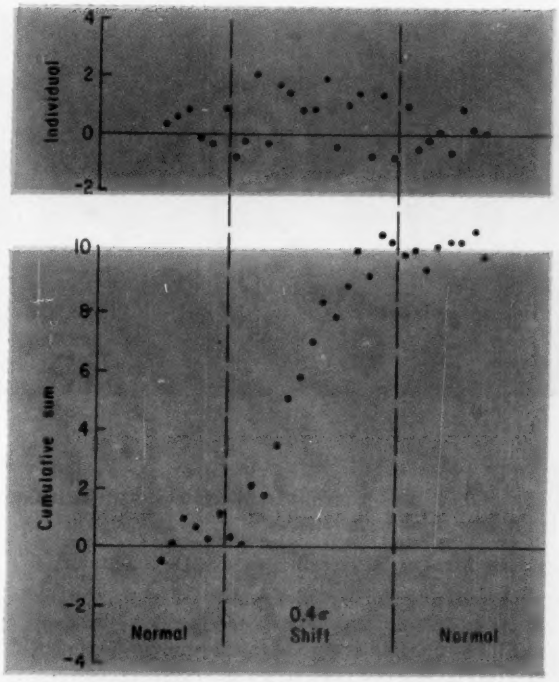
Within the last few years, several charting procedures have been suggested[1, 2, 12] that complement the detection power of the standard Shewhart chart. Of particular note is the Cumulative Sum chart on which the cumulative sum of the differences between batch yields and the process average are plotted. While the theory is somewhat obscure, and we have had only limited industrial experience with its application[12], the major advantages for this method of plotting appear to be twofold:

1. The cumulative sum chart will detect a shift in level faster than will a standard Shewhart chart.

2. The point in time at which the shift occurred is more sharply defined.

Fig. 1 illustrates this point. Used in tandem, the Shewhart chart and the cumulative sum chart should prove to be a very powerful engineering tool for quality analysis and control.

Chart detects change—Fig. 1



Consider Design of Experiments

Now suppose we consider those techniques that are generally known as design of experiments, and are primarily based on a system of inductive reasoning. Again, a shorthand illustration of the method might appear as follows:

1. Prepare list of potentially important variables in the manufacturing operation.

2. Change variables in a prescribed pattern.

3. Observe response.

4. Express quantitatively the relationship between control and response variables.

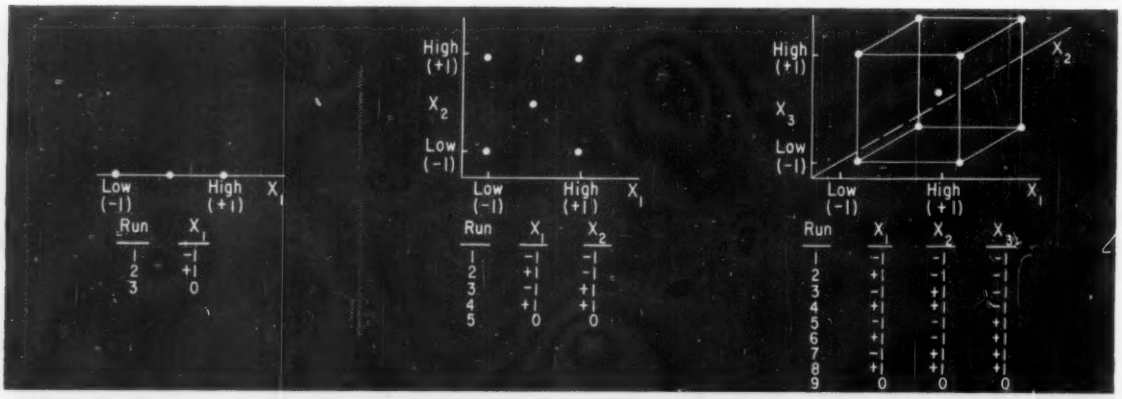
The real development in the field of experimental design took place over, roughly, the same period of time as statistical quality control although the origin was later and in a different field. The first authoritative text,[10] "The Design of Experiments," was written in 1935 by Sir Ronald A. Fisher. The book was primarily concerned with the application of designed experiments in the field of the natural sciences.

Fisher's book and work over the following few years was primarily aimed at designing experiments to test various levels of qualitative variables. A typical problem to the agriculturalist, for example, is to test for differences between types of wheat in various fields at agricultural stations throughout the country or world. Because of the emphasis on qualitative variables, only a mild interest was aroused in the chemical processing industries.

Not until 1951, when Dr. George E. P. Box[3] published his paper entitled "On The Experimental Attainment of Optimum Conditions," did we have development work on statistical methods primarily aimed at application in the chemical industry. Looking back over the intervening nine years, it is clear that following the publication of this paper, we had statistical methods that would efficiently aid the experimenter in two problem areas.

First, from earlier development work, we had designs that would allow us to determine which of several variables are actually important. Secondly, Box's paper indicated a procedure to locate the optimum settings of the important variables. More recently, we have been concerned with a third problem area; that is, the development of methods that use a theoretical

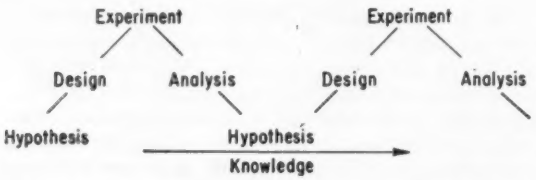
Process variables determine control limits—Fig. 2



approach to the determination of why the variables produce an indicated effect.

Experimental Design in Process Development

Before considering the details of these methods, it is important that we stop to consider how experimental design fits into the typical process development or process improvement program. An insight into this integration of techniques can probably best be gained by examination of the following diagram[1]:



In general, the physical or engineering scientist increases his knowledge by a sequential process of moving from hypothesis to experiment to a new or modified hypothesis to experiment, etc. Statistical methods will aid the experimenter in two stages of this process. Between the hypothesis and experiment, statistical methods will aid in the selection of an efficient experimental pattern. After the experiment is performed, statistical analysis will help to present the data in the most lucid and stimulating way for the further consideration of the experimenter.

Typical Program Explains Application

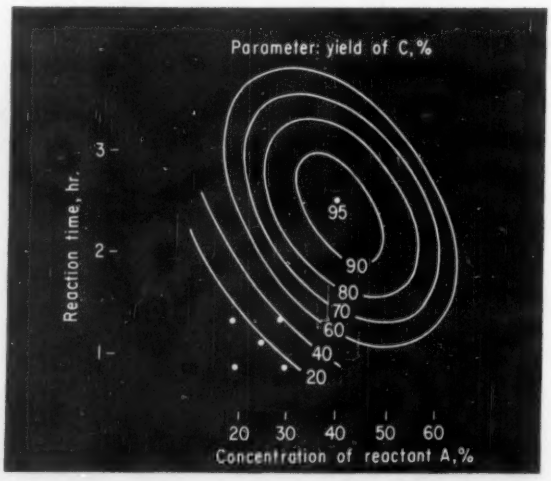
In order to discuss the application of experimental methods, let us follow a typical program from process development into the plant. The beginning point is that at which a development chemist is asked to optimize a reaction producing a desired product, C. Assuming that no prior effort has been made to optimize the various levels of the variables, we might imagine that yields are about 20% of theory.

Generally, the first problem that must be solved by the development chemist is that of deciding which of the many possible control variables are really important in terms of their effects on the chosen responses. A reasonable approach to deciding whether a single variable exerts some leverage on a response is to observe the yield produced under two different levels of that variable. If two or more variables are to be studied with this object in mind, we might choose a high and low level for each variable and perform experiments at all combinations of the levels. The resulting designs may be pictured as shown in Fig. 2.

It is certainly possible for the functional relationship between the x_i and y to be quadratic, that is, rising to a maximum and then falling off, and for the two selected points to straddle the maximum and indicate no effect. For this reason, a center point is usually added to the design as a partial safeguard.

It might at first appear that formulating the designs in more than three dimensions would be somewhat of

Contour diagram relates variables—Fig. 3



a problem. Notice, however, that if the high and low levels of each variable are coded as +1 and −1, respectively, the coordinates of the actual experimental runs form an easily identifiable and expandable pattern. This type of design is known as a 2" factorial, where n represents the number of variables, each examined at two levels.

Once the number of variables to be studied has been decided, several decisions must be made before choosing a specific design. Among these decisions are the following:

1. Specific form in which each variable is to be studied must be chosen. For example, instead of varying temperature in deg. C., we might choose the inverse of degrees absolute. Instead of concentration, we might use the logarithm of concentration.

2. Range over which each variable is to be studied must be selected. Certainly, one of the things influencing this choice is the experimenter's best guess, based on prior knowledge, of the probable functional relationship between the control variables and the response.

3. As the number of variables becomes large, the total number of combinations of levels, and, therefore, number of experimental runs, should be quite large. It is usually possible under certain reasonable assumptions to select a portion of the design to be run and analyzed. In the language of the statistician, this is called "fractionation" of the design.

How to Determine Optimum Conditions

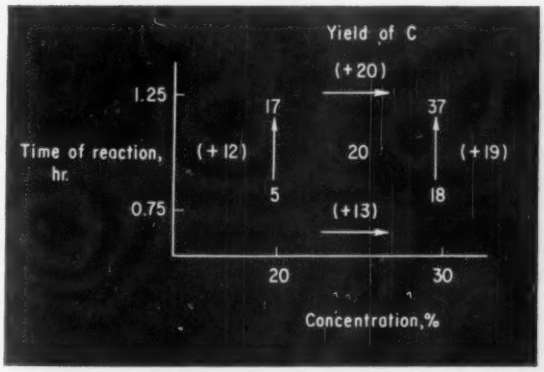
To illustrate the analysis of these designs, let us return to the problem facing the development chemist. Suppose that after careful thought, he decides to experiment with only two variables: concentration of reactant A, x_1, and reaction time, x_2. Let us further assume that, unknown to the chemist, the true relationship between x_1 and x_2 and the yield of product C is given by the "response surface," or "contour diagram" given in Fig. 3.

The best conditions known to him initially are 25% concentration of reactant A and 1-hr. reaction time. He decides to study a range of 20% to 30% concentration and 0.75 to 1.25 hr. in reaction time. He might get the data shown in the following table and Fig. 4:

Initial Concentration	Reaction Time	Yield
20	0.75	5
30	0.75	18
20	1.25	17
30	1.25	37
25	1.0	20

To estimate the effect on yield of changing concentration from 20 to 30%, it seems reasonable to calculate the difference in yield between the two runs at 0.75 hr. and the two runs at 1.25 hr. As illustrated, these differences are 13% and 20%. Since both of these are measured by a difference in two observations and, hence, are equally good measures of the time effect, it further seems reasonable to average them, obtaining an estimated concentration effect of 16.5%.

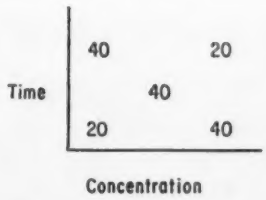
How changes affect yield—Fig. 4



The best guess, therefore, as to what happens when concentration is changed from 20% to 30% is that the yield will increase by 16.5%. In like manner, changing time from 0.75 to 1.25 hr. may be calculated as the average of 12% and 19%, or 15.5%. Again, our best guess as to what happens when time is changed from 0.75 to 1.25 hr. is that the yield will increase by 15.5%.

While the previous discussion describes the rational for calculating the concentration and time effects, arithmetically the same results are obtained for any number of variables by calculating the difference between the average at the high level of each variable and the average at the low level of each variable. Note, for example, that the concentration effect may be calculated as the average of 37 and 18 minus the average of 5 and 17, or 16.5% as was obtained before.

This particular design allows the estimation of an additional effect, which is illustrated by the exaggerated data in the figure below.



A quick glance at the sketch indicates that both the estimated concentration and time effects are equal to zero. This is rather a peculiar situation inasmuch as the numbers are not identical. Careful examination of the data enables us to see the difficulty. For example, observe that at the low level of time, changing concentration from 20% to 30% appears to increase the yield by 20%, while at the high level of time, changing concentration from 20% to 30% appears to decrease the yield by 20%. This same situation exists with respect to time.

There is an apparent interdependence between the

variables in their effect on yield, or, in the jargon of the statistician, "interaction." The influence of this interaction on the interpretation of the results is that no general statement about the effect of one variable on the response can be made without specifying the level of the other.

Geometrically, it means that the relationship between the control variables and the response cannot be described by a plane but must be represented by a curved surface. Arithmetically, this interaction effect may be measured by calculating the differences between the averages taken across the diagonals of the square. In our original example, the interaction effect is 21% minus 17.5%, or 3.5%.

A comparison of the center point with the average of the peripheral points provides the second measure of possible curvature. For our example, this "lack of fit" may be calculated as 20 minus 19.25 equals 0.75%.

It is important to recognize that all peripheral observations are used in the calculation of the concentration, time and concentration by time interaction effects. Consequently, the calculated effects contain the maximum information available from the data about the true effects. This characteristic is described in statistical terms as maximum efficiency.

We have been quite careful to say that the effect calculated from the experimental design is our best guess of the true effect. While each of our experimental points is doing its level best to estimate the true yield at the indicated set of conditions, nevertheless it will differ from the true value because of experimental variation.

Before the importance of these effects can be appropriately determined, we must have some knowledge of the size of experimental variation. This can be obtained quite readily, usually from repeated runs within the experimental design itself, occasionally from some external source or from the technique[8] of "half-normal plots." If a measure to this experimental variation is available, statements like that shown below for the range of possible values for the true effects can be made. For example, estimated concentration effect plus or minus a measure of variation is: 16.5% ± 8%.

Probability:

$$\underset{\text{effect}}{\text{True}} \quad [8.5\% \leq \text{concentration} \leq 24.5\%] = 0.95$$

The statement shown says that all hypothesized values for the true concentration effect that lie between 8.5% and 24.5% are reasonable at the 95% level of probability. That is, if concentration is increased from 20% to 30%, we can expect to get a yield increase of at least 8.5% and perhaps as much as 24.5%.

If the following statement had been obtained, Probability:

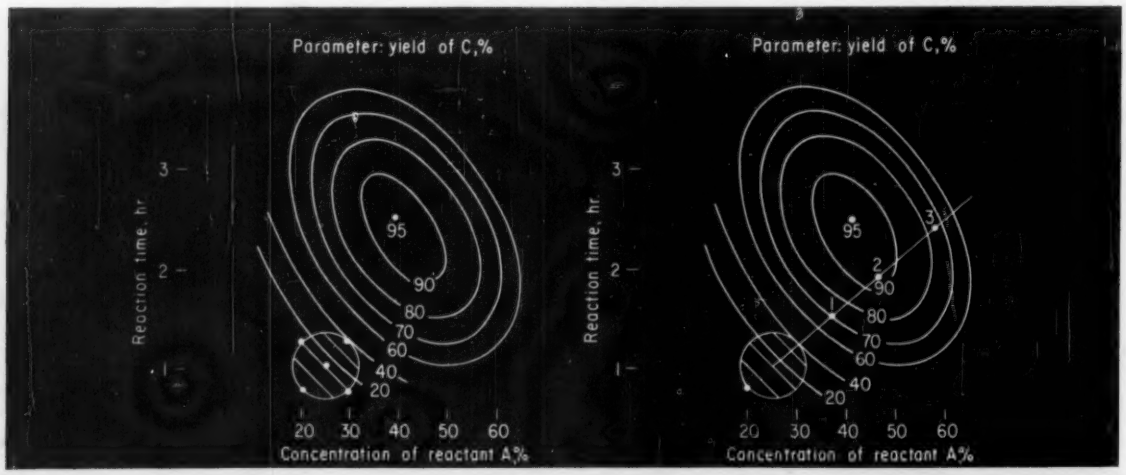
$$\underset{\text{effect}}{\text{True}} \quad [-3.5 \leq \text{concentration} \leq 36.5] = 0.95$$

we would say that the effect of changing concentration from 20% to 30% might be to decrease the yield by as much as 3.5% or to increase it by as much as 36.5%. Note that the hypothesis, that changing concentration over the indicated range will do nothing to the yield (true concentration effect equals zero), is tenable.

We might decide in this case either to drop concentration as a variable for consideration, change the range over which it is being studied, or to increase the number of experiments to obtain a better estimate of it. As will be seen in a little more detail later on, the size of these intervals depends directly on the variation of the data, the degree of knowledge of that variation, the experimental design itself and, of course, the chosen level of probability.

If we assume that an appropriate calculation pro-

Plot model on contour diagram—Fig. 5 Show experiments on contour diagram—Fig. 6



duces a confidence interval around the concentration effect of 16.5 ±8.0, we may then proceed to tabulate the analysis.

Concentration	16.5 ± 8.0
Time	15.5 ± 8.0
Concentration and time	3.5 ± 8.0
Lack of fit	0.75 ± 9.0

Notice that since the concentration, time and concentration by time effects are all calculated from the same data, the size of the interval about each is the same. The lack-of-fit statistic is slightly less precise with the resultant ±9.

An examination of these intervals suggests first that since the statistics measuring curvature, that is interaction and lack of fit, are small, the relationship between time, concentration and yield may be described geometrically as a plane. Secondly, it appears that both time and concentration are important. A glance at the data suggests that higher concentration and longer time will produce increased yield. However, we can be somewhat more precise about this point.

The algebraic equation for a plane may be written as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2$$

If we adopt the following coding mechanisms,

$$x_1 = \frac{\text{concentration (\%)} - 25}{5}$$

$$x_2 = \frac{\text{Time (hr.)} - 2.5}{0.25}$$

which merely formalize the earlier convention of calling the low level of a variable −1 and the high level of a variable +1, the unknown coefficients may be estimated as follows:

$$\beta_0 \longleftarrow b_0 = \frac{\Sigma y}{n} = \bar{y}$$

where $\bar{y}$ = average of all n observations.

$$\beta_1 \longleftarrow b_1 = \tfrac{1}{2} \text{ (Concentration effect)}$$
$$\beta_2 \longleftarrow b_2 = \tfrac{1}{2} \text{ (Time effect)}$$

For our data, the fitted model becomes:

$$y = 19.4 + 8.25 x_1 + 7.75 x_2$$

For this model, every hypothesized yield may be represented by a straight line giving varous combinations of x_1 and x_2, all of which will produce the assumed yield. These can be plotted on the contour diagram given in Fig. 5.

Model Indicates Directions for Change

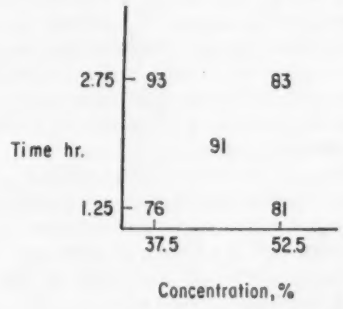
Based on our data, we would expect to move toward improved yield in the most rapid possible way by running further experiments along a path perpendicular to the contours. This path, called the path of steepest ascent, is actually given directly by the model. We will move perpendicular to the contours if further experiments are run at various points where the ratio of x_1 to x_2 in terms of the coded units is 8.25 to 7.75.

Exactly how big a jump to take is entirely up to the experimenter. For example, on the basis of his knowledge of the system, how much faith does the experimenter have in the extrapolative power of the model? How expensive are individual experiments? What are the consequences of a bad run?

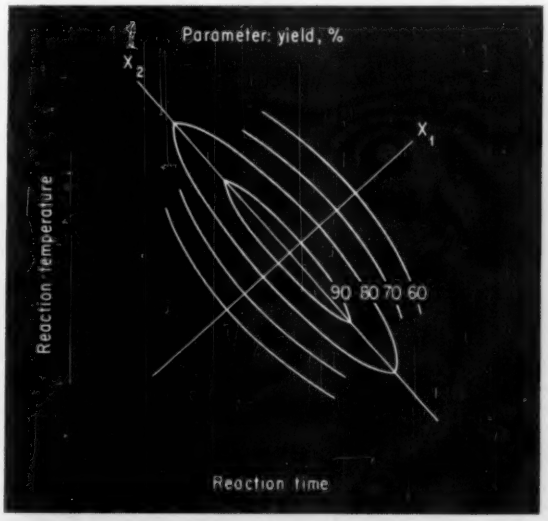
Suppose we run the experiments indicated in Fig. 6. We would find that the rise from Experiment 1 to Experiment 2, followed by the decrease to Experiment 3, would suggest that around Point 2, a second experimental design should be established. Suppose the experimenter decides that, since he appears to be in the area of maximum yield, he should increase the size of the region to be studied. A reasonable set of data along with an analysis, again assuming confidence intervals of the same size as were found earlier, appears below.

Concentration	Time	Yield
37.5	1.25	76
52.5	1.25	81
37.5	2.75	93
52.5	2.75	83
45.0	2.00	91

Concentration	9.5 ±8
Time	−2.5 ±8
Concentration and time	7.5 ±8
Lack of fit	7.75±9



Example may give this response—Fig. 7



This time the concentration by time and lack-of-fit terms are not small, and the assumption of a linear or first-order relationship between concentration, time and yield becomes extremely risky. Our recourse is to augment this design with some additional points that will allow the estimation of constants in a second order model, which appears below for two variables.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_{11} x_1^2 + \beta_{22} x_2^2 + \beta_{12} x_1 x_2$$

A particularly convenient design for estimating constants in this model may be formed by simply adding a second 2^2 factorial with the center point rotated 90° with respect to the first design. This experimental design is called a "central composite" design. A model that fits our hypothesized surface is as follows:

$$y = 95.00 + 0.05 x_1 - 1.58 x_2 - 8.13 x_1^2 - 5.87 x_2^2 - 6.25 x_1 x_2$$

If the analysis associated with the second-order model indicates good agreement between the observed and predicted data, and provided that the number of control variables is not excessively large, a contour diagram can be calculated and drawn. It is then possible to observe visually the nature of the relationship, the location of the point of maximum yield, etc.

When the number of control variables is large, we can perform additional algebraic manipulations to help us grasp the relationships. For example, we can partially differentiate the model with respect to each variable, set each resultant equation equal to zero, and solve the set of equations simultaneously, to obtain the predicted maximum or minimum.

In addition, it is frequently possible to obtain a better understanding of the factor dependency by reducing the fitted second-order model to its "canonical" form. As illustrated in all analytic geometry texts, the analysis consists simply of rewriting the full second-order model in an equivalent form.

$$y - y_s = \beta_{11} X_1^2 + \beta_{22} X_2^2$$

For our example:

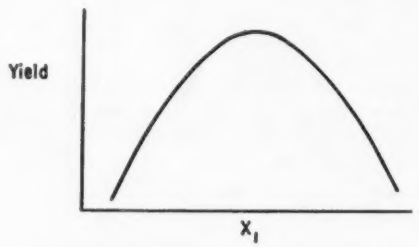
$$y - 95.13 = -10.3 X_1^2 - 4.3 X_2^2$$

The canonical model is of value in two ways:

1. Relative size and sign of the coefficients suggests the type of geometrical response surface. For example, with two variables, if both signs and the size of the coefficients are the same, the contour system is essentially circular. If the signs are the same but the absolute value of the coefficients differ, the system is elliptical. This is the situation in our example. The greater the disparity between the size of the coefficients, the greater will be the attenuation of the resulting ellipses.

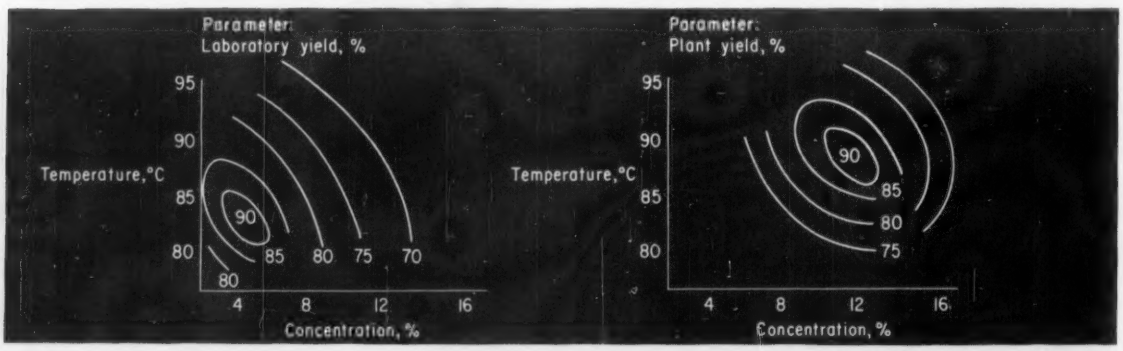
2. Canonical analysis may suggest ways[13] of reparameterizing the model with a resultant gain in the fundamental understanding of the system. Again, consider an example. Suppose the response surface shown in Fig. 7 is obtained after making changes in the parameters.

The new coordinates, pivoted about the center of the system, would appear as indicated. Note from the diagram that as conditions are changed along any path parallel to X_2, very little change is produced in the response. As conditions are changed parallel to X_1, the response changes very rapidly. This may mean that all of the information in the system is contained in X_1. By plotting the yield against reaction time X_1, we can describe this information in the following diagram that emphasizes the relation of the two variables:



Remembering that $X_1 = f(x_1 x_2)$, this analysis may suggest to the experimenter some single physical variable that is controlling the system, where previously two had been considered. For example, where two variables, time and temperature, had been considered

Compare laboratory to plant performances—Fig. 8



in an endothermic reaction, the anlysis might suggest that there is really only one variable, say, total heat input, which is a combination of the original two.

Suppose Data Do Not Fit

Now suppose that the analysis of the data suggests that the second-order model does not fit the data appropriately. This is to say that the $\Sigma (y_i - y_i')^2$ (the sum of squares of the deviations between the observed and predicted points) is larger than can be explained by experimental variation. While this can occur for any one of a number of reasons, including extraneous or incorrect observations, in a well-behaved system the reason may be that the variable metrics were improperly chosen.

There is a procedure that allows the data to suggest appropriate transformations of the control variables that will improve the fit of the model.[8] In effect, the data are used to fit a model of the following type:

$$y = \beta_0 + \beta_1 x_1^{\alpha 1} + \beta_2 x_2^{\alpha 2} + \ldots + \beta_n x_n^{\alpha n}$$

This model has the power to suggest a variety of possible transformations on the x's. If, for example, the predicted value for any α approaches -1, inverse of the original variable might be considered to be appropriate. In like manner, it can be shown that as the predicted value for α approaches zero, an appropriate transformation for x is $\log x$.

Suppose that the development chemist has determined a second-order model that fits the data adequately, and the process is subsequently installed in a plant. We proceed through the customary startup difficulties and finally declare the process to be on stream. Unfortunately, it is found after a period of sustained operation at the best conditions of 40% concentration and 2½ hr. reaction time that the yield is not, in fact, 95% but 85%.

This phenomenon, which occurs all too frequently, leads one initially to postulate all manners of ways in which the experimental work might have been in error. Upon reflection what has probably happened is indicated by the contour diagram shown in Fig. 8.

When a process is transferred from the laboratory or pilot plant into full-scale equipment, unquestionably the relationship between the variables remains approximately the same. For example, if it is found in the laboratory that the contour system is essentially elliptical with a clearly defined maximum, the same contour system with perhaps some slight distortion will be found in the plant. However, the position of the response surface is likely to be drastically shifted in the plant equipment.

Application to Plant Operation

When serious difficulties are encountered in operating the plant, or when there is reason to expect that major improvements could be rapidly obtained, it may be wise to turn the plant over to experimental operation for a short period of time. By using a carefully chosen statistical pattern, it is possible to test many factors in a limited period of time.

Of course, several major difficulties are encountered with this approach. By its very nature, the design will upset production, and usually special facilities and personnel will be needed to insure that the complex array of experiments is properly carried through. In addition, and perhaps even more important, it must be expected that some batches, as designated by the design, will produce very low yields, high levels of impurity, etc. We would certainly be willing to use a designed experiment in the plant when faced with a very sick process and the necessity for a reasonably fast cure.

However, the vast majority of processes are just slightly ill and, when faced with the prospect of an experiment disrupting production, management frequently decides that the cure is worse than the disease. If our process is profitable at 85% yield, and if sales of the product are heavy, the motivation to approve a full-scale experimental program is very weak. A technique for optimizing a process under the constraints associated with plant operation is called Evolutionary Operation,[6, 11] often abbreviated as EVOP.

The name for this technique was chosen because it attempts to emulate natural evolution in a manufacturing facility. Evolutionary operation, like natural evolution, has two essential elements: (1) variation and (2) selection.

Slight variation is artificially introduced into the manufacturing process in such a way that there is little danger of producing unsatisfactory material, production is not disrupted and the normal working force can continue to operate the plant. Selection is introduced by presenting the accumulated data to the process supervisor in an easily interpreted fashion. Evolutionary operation is, therefore, a permanent method of plant operation, not something applied on a short-term basis. It works by gradually pushing the process toward its optimum operating conditions.

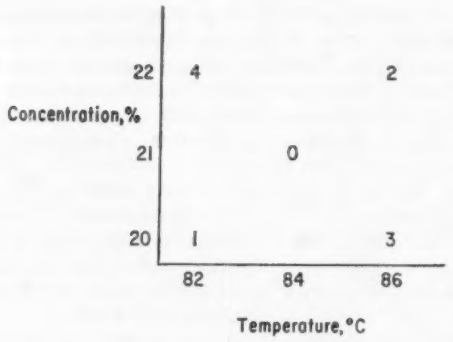
Slight variation is introduced into the process on two or three control variables by using either a 2^2 or 2^3 pattern discussed earlier. The changes are made sufficiently small that there is no danger of detecting changes in individual batches, or units produced by the process. Continued manufacture of material under the conditions described by the pattern will allow information to accumulate. To quote from Dr. Box:

"The effects of the deliberate changes in the variables will usually be masked by large errors customarily found on the full scale. However, since production will continue anyway, a cycle of variants that does not significantly affect production can be run almost indefinitely, and because of constant repetition, the effect of small changes can be detected."

The second essential component, selection, is supplied by presenting the data to the process supervisor on an "information board." Generally speaking, accumulated data are continuously recorded on the board in the process supervisor's office in such a way that he can at any time determine the advisability of moving the pattern, the cost of the program, etc.

Example Explains Evolutionary Operation

As has already been mentioned, the first important aspect of evolutionary operation is that changes in the control variables are made according to a prescribed pattern. The following diagram shows the pattern for two control variables, where the ranges selected for temperature and concentration have been judged to be small by the operating personnel.



Position zero represents the standard operating conditions of temperature and concentration, while Positions 1, 2, 3 and 4 represent changes in the variables. If this is a batch process, batches will be made successively at each of the five positions in the order 0, 1, 2, 3, 4; 0, 1, 2, 3, 4, etc. Each set of five runs is known as a cycle. When it is convenient to do so, the order in which batches are produced is randomized. The data are then tabulated on the information board.

In this example, the program is still in Phase 1, that is the pattern is still operating about the original conditions. Seven cycles have been completed. Shown at the top of the table are the responses being considered and the requirements for each. Below that appear the running averages calculated through the seventh cycle. These are posted in such a way as to make the relationship between the variables as clear as possible. Since these averages are estimates of the true response under the given conditions, it is essential that a measure of their reliability be available.

This is provided by the 95% error limits. These limits are calculated by use of the formula $\pm ts/\sqrt{n}$, where n is the number of cycles completed, s is the estimated standard deviation and t is the appropriate quantity chosen from a table of the t-distribution. A variety of probability levels is available in the table. It is clear from the formula that the program can be continued until the quantity $ts/\sqrt{n}$ is reduced to any desired size.

Following this are the effects and their 95% error limits. These effects are calculated in the same manner as was described earlier with the single exception of the effect here called "change in mean." The change in mean is calculated by the average of all five points compared with the average at the center. This has been done so that the statistic provides an estimate of the cost of introducing evolutionary operation.

On the basis of the data supplied on the information board, the process supervisor can decide after any cycle whether the process should continue to cycle around the initial pattern, or whether the operation should be modified. If the supervisor decides to modify the operation, several possible choices are:

1. Relocate the pattern so that one of the corner points becomes the new center.
2. Lengthen the interval over which one or both of the variables is being examined.
3. Explore a path that is indicated as leading toward improved conditions.
4. Replace the old variables with new ones.

Concerning the number of variables that can be conveniently run, it has been our experience that two-variable programs are probably to be preferred for inauguration purposes. However, as production personnel have become familiar with the technique, it is

Phase 1 — **Information Board** — Cycle 7

Response	Yield	Percent Impurity
Requirement	Maximum	Minimum
Running averages	Concentration, %: 22: 525, 490; 21: 530; 20: 540, 531 — Temperature, deg. C: 82, 84, 86	Concentration, %: 22: 3.8, 4.7; 21: 4.1; 20: 3.8, 4.4 — Temperature, deg. C: 82, 84, 86
95% Error limits	±20	±20
Effects with 95% error limits — *Temp.*	−22.0 ±20	0.75 ±0.58
Conc.	−28.0 ±20	0.15 ±0.58
C & T	−13.0 ±20	0.15 ±0.58
Change in mean	− 6.8 ±18	0.06 ±0.52

desirable to take advantage of the increased efficiency of the three-variable pattern.

When it has been agreed that an evolutionary operation program should be initiated on a given process, a choice of control variables must be made. As the program proceeds, the effect of these variables will decrease as they approach their optimum levels. Consequently, when their possible additional contribution reaches an economic minimum, they will be dropped from the program in favor of new variables. Therefore, a continuing supply of ideas regarding possible control variables is essential.

For this purpose, committees comprised of people having different disciplines and with interest in the process should be established. The nucleus of such a committee might be the manufacturing supervisor, a research chemist thoroughly familiar with the reaction, and a chemical engineer who has had experience with the type of equipment used in the process. The major function of this committee is to advise the process supervisor in the operation of the program. During meetings held for the purpose of interpreting the results, ideas for modification will be generated.

Articles describing actual examples of evolutionary operation are exceedingly scarce. This is simply because it is exceedingly difficult to describe evolutionary operation programs without literally discussing process conditions or, on the other extreme, without reducing the example to an inanity. However, many economically successful applications of EVOP have been reported at meetings. At American Cyanamid, we view evolutionary operation as an exceedingly valuable process improvement tool.

The obvious extension of the experimental work, which really attacks the problem of why the reaction behaves as it does, is to fit theoretically based models rather than Taylor series polynomials. Much of the work in this area is new because most theoretical models demand the use of a computer in the estimation of the unknown parameters.

The advantage of a theoretical model can be considerable depending upon the use to which the model will be put. The advantage, generally speaking, occurs because the prediction power of the model is not limited to the region of experimentation, as is the case with empirical models. A theoretical model will allow the experimenter to simulate the process over an almost unlimited region, supplying valuable information for design and control purposes.

Basis for Theoretical Model

To illustrate the origin of theoretical models, consider the following example from kinetics:

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$

If we describe the rate of change of concentration of each of the components and solve the resulting set of equations simultaneously, we find:

$$C_B = \frac{C_{A_o} k_1}{k_2 - k_1} (e^{-m} - e^{-n})$$

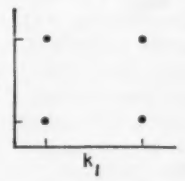
where C_B = Concentration of reactant B at anytime t.
C_{A_o} = Initial concentration of reactant A.
k_1 and k_2 = Reaction rate constants.
$m = k_1 t$
$n = k_2 t$

The problem is to estimate the reaction rate constants and determine their dependence on temperature. Consider the estimation problem, assuming that data are available. First, notice that the model is nonlinear with respect to the unknown parameters and cannot be linearized by any type of transformation.

Unfortunately, most sets of differential equations describing reactant concentrations for all but the simplest reactions generate nonlinear models. Unhappily, the practical consequence of a nonlinear model is that an explicit least-squares solution for the reaction rate constants does not exist. They must be estimated by iterative procedures.

While the following procedure has not been found to be particularly successful in computer solution, it illustrates the iterative approach. Suppose the following data are given:

Time	Concentration
t_0	C_0
t_1	C_1
•	•
•	•
•	•
t_n	C_n



It is certainly possible to guess four sets of values for k_1 and k_2 according to a 2^2 factorial pattern.

For each pair of guessed constants let us compute the predicted concentration C_i' at each t_i. We can further calculate $\Sigma (C_i - C_i')^2$ for each pair of constants. Since, by the least-squares criterion, the best choice of k_1 and k_2 is at the point where $\Sigma (C_i - C_i')^2$ is a minimum, we can now program the computer to follow a path of steepest descent toward the minimum residual sum of squares.

When the k's are estimated and their dependence on temperature is known, assuming that the process is reaction controlled, we can experiment on the computer to locate those conditions that will favor the production of the desired constituent. The analog computer is particularly efficient for this purpose.

In practice, several problems have been encountered with this approach. For example, depending on the complexity of the surface for $\Sigma (C_i - C')^2$, the computer may converge very slowly. Secondly, there is a problem of the possible existence of local minima toward which the computer may unknowingly converge. Some progress,[14] using modified iterative methods, is being made toward a generalized solution of nonlinear models.

The problem of data collection, that is the design of experiments for nonlinear models,[7] has not been considered extensively as yet and much work remains to

be done. As an example of the strange design situation that is encountered, unlike linear models, designs that provide the best estimates of the parameters will not provide the best estimates of the response.

It might be mentioned that the use of the stirred-tank reactor for investigating kinetics, which substantially uses material-balance information to avoid a nonlinear model, has proven to be of considerable value. Interestingly, and because of the linear models, the 2^n factorial designs appear to be of value for investigation of kinetics by stirred-tank reactors.

Basic mechanism studies are unquestionably expensive and, despite some reduction in cost as our experience and knowledge grows, are likely to remain so. Yet, in large-volume processes, this approach is likely to be the most economic.

Conclusion

The primary purpose of this paper was to survey the available statistical methods that have been found of value in the areas of process improvement and process development.

In the analysis of existing data, the application of graphical procedures to display the data in the most illuminating way was emphasized. Mention of computer analysis of past data was not excluded accidentally. Unfortunately, while necessary arithmetic is perhaps reduced, it is also necessary to supply the computer with a hypothesized model. Yet, the very hope in examining past data is that they will suggest some new, previously undiscovered, hypothesis regarding the nature of the process or reaction. Thus, the purpose of the analysis and the requirements for computer analysis are completely at odds.

The most powerful technique for presenting data is clearly that which allows the mind of the scientist to range in the widest possible way. Some form of graphical presentation appears to offer the greatest potential.

In discussing the techniques of experimental design that are based on inductive reasoning, the progress of a study of a reaction from the laboratory to the plant was described. In doing so, we successively answered the question of which of the variables are important, how the variables affect the response both in the laboratory and plant and, finally, why the process behaves as it does.

In practice, we seldom proceed over the entire path from screening experiments to theoretical studies. Sometimes, it is adequate merely to screen the variables. In other situations, appropriate theoretical models must be determined, and we begin at this point. The point of entrance or exit from the course of study is a question of economics. Generally speaking, the farther a study proceeds from screening to the fitting of the theoretical model, the more data are necessary, the more difficult the data are to obtain, and the more expensive the study becomes.

As soon as some feeling is obtained for the degree of optimization that can be achieved with a given amount of data, the economic limit of the study can be approximately determined. The sequential performance of experiments in very small blocks not only allows the experimenter to use his theoretical knowledge in the most efficient way but continuously improves his feeling for the relationship between the amount of study and the degree of optimization.

The application of mathematical and statistical methods has proven to be a strong economic lever in the chemical industry. Part of the responsibility for future growth clearly rests with statisticians and mathematicians. There is a need for new and more powerful techniques particularly in nonlinear models. An equal responsibility rests with the physical and engineering scientist to become knowledgable in the use of these techniques.

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Of all the disciplines that seek to generalize our increasingly complex technology, systems engineering may prove to be the key to greater and more profitable understanding. In this article, a chemical engineer from the petroleum industry speaks out with views based on experience.

Chemical Process Systems Engineering

THOMAS C. WHERRY, *Phillips Petroleum Co.*

Systems engineering, although not new in practice, is receiving greatly increased recognition and attention. The systems concept in engineering has developed to meet the challenge of our modern complex technology. Since chemical and petrochemical processes are complex systems, chemical engineers should find the subject especially interesting and useful. Let us begin with a few ideas of what constitutes a system and what systems engineering entails.

A system is an integrated assembly of components which when grouped together perform a set of specific functions.

There are many kinds of systems, some inactive such as a highway system and some active such as the telephone system. Some, from our viewpoint, are uncontrollable, like our solar system. Controllable systems include traffic systems, railroads, production lines, chemical and petrochemical processes. It is the active, controllable systems upon which our attention is focused.

Virtually anything can be looked upon as a system. It is an elementary component, indeed, whose function is so simple that it obviously is not a system. A stirred reactor, a fractionator, or an electrically driven pump meet the requirements of our description of a system, but they are also components of larger systems.

Systems engineering comprises a disciplined, theoretically defensible study of systems. The study includes analysis of a problem, synthesis of a solution and evaluation of the solution. It is then necessary, perhaps, to distinguish between systems engineering and operations research. Current usage of these terms indicates that the division is determined by the type of system rather than the type of approach. Systems engineering is more often applied to active, controllable, physical systems that are largely hardware. On the other hand, operations research seems to be applied to management or organization systems, such as marketing, selling and distribution.

Most people believe it's really only worthwhile to consider systems engineering as applicable to relatively large systems. Perhaps we can visualize relatively small systems in their totality and have no trouble treating all integrated components simultaneously; the relationship and interdependence of the parts is clear. This is not so with very large systems. At some point in complexity, it becomes impossible for us to retain a picture of the whole system or to generate a satisfactory quantitative description. Attempts to simplify this formidable task have led to a piecemeal approach to analysis and synthesis of complex systems.

But this situation is changing. A number of factors seem to be responsible for a rather revolutionary development in technology. Among them are development of digital and analog computers and improved methods of measurement. Others include recent developments in automatic control theory and use of applicable mathematical methods. These are some of the tools that make it possible to handle complex, interdependent relationships. Perhaps the biggest single factor is the force of economic competition.

Systems and the Chemical Engineer

Chemical engineers work with systems. In fact, chemical engineering consolidated chemistry and mechanical engineering to design and operate complex chemical processes. It's proper to acknowledge that many, perhaps most, chemical engineers actually practice systems engineering to some degree and have been doing so for many years. However, although intuitive and empirical techniques were once capable of achieving important results, they are now becoming outdated by the new, evolving methodology of systems engineering.

Systems engineering can be applied to a wide variety of systems and is a discipline in its own right. It requires people with specialized training. It calls for

substantial revision of engineering organizations. The practice of systems engineering, however, is not new. It was used to engineer our modern telephone system and to develop our modern television service. The extension of weapons systems since World War II has probably provided the greatest push in the development of the systems approach.

These weapons systems could be developed and applied only through a rigorous scientific attack on the over-all problem. We now recognize and appreciate the universal value of systems engineering in solving extremely difficult problems in today's complex engineering developments. Systems engineering involves disciplines that cut across all the normally academically separated technical and economic fields. Systems studies are usually conducted by teams that include chemical, electrical and mechanical engineers, chemists, mathematicians, physicists and many others, depending upon the particular system.

The interdisciplinary nature of systems engineering is having a significant effect on engineering education. It is noticeable that many more schools have instituted courses in engineering physics or general engineering to broaden the technical background of their graduates. But these actions are only the beginning of the changes to occur within the next five to ten years.

Education for Systems Engineering

The Case Institute of Technology, at Cleveland, Ohio, seems to be pioneering in the education of systems engineers. It has established a Systems Research Center for research and graduate study, operating in direct cooperation with several departments and groups: chemistry and chemical engineering, civil engineering, computing center, electrical engineering, engineering design center, humanities, management, mechanical engineering, mathematics and operations research. The center operates to bring together faculty and students in an environment that promotes the development of techniques applicable to the solution of systems problems. Professor Donald P. Eckman, who heads the school's new Systems Research Center, has made some interesting comments:

"The traditional division of engineering into electrical, chemical, civil and mechanical disciplines is not only just inadequate, it is actually handicapping the growth of development of better engineering technology. Its only justification, if any, lies with the human necessity for motivation in the hard work of study. A better means for motivation may be found in a reorientation of the traditional divisions toward materials, power, communications, control and systems, regardless of the specific tools in use.

"With a sound foundation in basic science and engineering, a strong emphasis is required in three areas at least. Those are mathematics, dynamics and control."

In asking that traditional engineering training in mathematics be extended, Eckman includes such topics as differential equations, numerical methods, probability, complex variables, transforms and Boolean algebra. He believes that dynamics is the underlying foundation for analysis in modern engineering and that its study is essential. In addition to the conventional dynamics of rigid bodies and electric circuits, a much broader study must be included in the training of the engineer. Extension into the following areas is indicated: lumped-parameter systems, distributed-parameter systems, discrete systems and stochastic systems.

Automatic control is employed in every phase of modern industry and its usefulness is extending to more than simple control of system variables. It now includes use of feedback and feedforward techniques for improvement of system performance. The following fields of study are producing important results: control theory, nonlinear control, discontinuous control, quantized control, statistical control and optimizing (adaptive) control.

Choosing Systems Objectives

In making a systems study, it is necessary to start by determining and defining the objectives. In the process industries, systems engineering has two major interests: designing an optimum plant or optimizing the operations of an existing plant. In either case, it is not easy for the systems analyst to define the actual objectives. What he needs to know to define them must be obtained in large part from the analysis. Charles J. Hitch of RAND Corp. has said, "We have never undertaken a major system at RAND in which we were able to define satisfactory objectives at the beginning of the study."

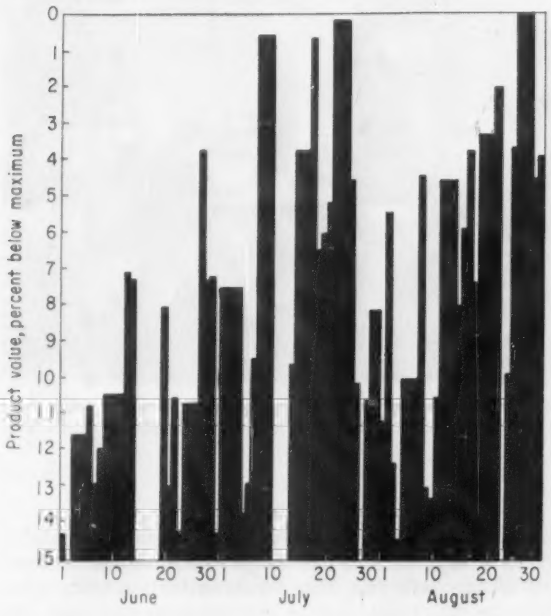
This is not an irresolvable impasse, but rather a common problem in any planned, systematically ordered extension of technology. It is resolved by developing the best objectives possible with a reasonable amount of effort, then proceeding with the analysis. As the analysis is carried out, the objectives can be revised to conform to the constantly developing process system. It is an iterative procedure. The system study and the objective unfold together. One of the beneficial results that arises in studying a system is increased knowledge about its objectives.

To state accurately the purposes for which any system is operated, it is necessary to know the objectives of the next larger system of which it is a component. To properly understand this objective, it will probably be found desirable to proceed to the second larger system. In an industrial operation process, this usually ends with company objectives. In fact, company objectives are a good starting point in some cases. Fortunately, the need for detailed knowledge of the objective diminishes as one proceeds up the system scale. The important thing is that the systems engineer must develop and define the objectives he is trying to achieve.

Objectives are multiple and conflicting. Here are some of the things that must be considered:

1. What performance level is desired? In a chemical process, this includes quantity and quality

Product value is far from steady—Fig. 1



of product, reliability and efficiency. Market studies provide information as to how much material is required.

2. What is the cost? This includes cost of equipment, maintenance cost, operating cost and losses due to downtime. Reliability also affects cost. In the chemical industry, there is a big payout for being first with a new product. This has to be balanced by the increased cost of the extraordinary effort required to get an earlier answer.
3. What are the constraints? This includes such considerations as capability of the people, state of the art and the manufacturing equipment available.

The Man-Machine Relationship

In any system, and this is especially true of a chemical or petrochemical process, the man-machine relationship deserves attention. Application of advanced system technology makes it necessary to examine this much more carefully than in the past. The people acting in direct contact with the process are themselves important components. Study of the situation as it exists in our present plants could lead to significant improvements. As the system or plant is changed by advancing technology, it is even more necessary to include the man-machine relationship in analyzing, designing and evaluating the system. More information concerning human engineering is required by new technology.

And the object is not to eliminate man–process relationships but to use them in the most effective way. This means minimizing unpleasant routine tasks while making the most of man's ability to adjust his actions to unforeseen circumstances and perform diverse calculations. It means studying communications to improve accuracy and speed of transmitting information. It also means many other things too numerous to go into here.

Performance of the plant is as much a function of the human behavior of the people as of the factors that are fed in through their equipment. For instance, what can happen if a man comes to work after an argument with his wife, or if at lunch there is no spoon in his lunch basket, or if he is irritated by one of the process engineers? And an interesting situation arises when a maintenance man leaves his coat in a heat exchanger. These circumstances are disconcerting and often expensive, but they're part of the problem and must be considered.

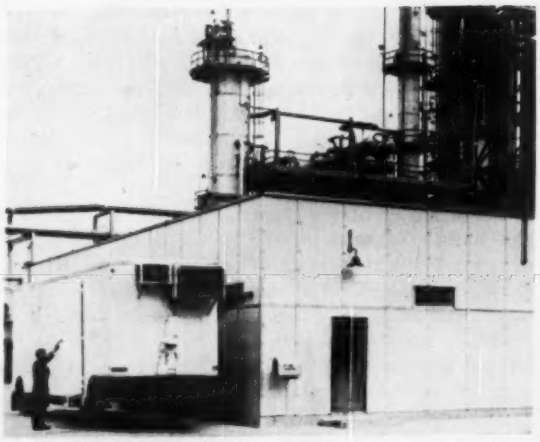
Automation Requires Systems Engineering

Automation is one of the largest single factors in man's ability to produce goods and services; its goal is increased productivity. The chemical and petroleum industry now has a moderate degree of automation that gradually evolved. We can't afford to wait, however, for an evolutionary growth, because of intercompany and international competition. The steps must be great.

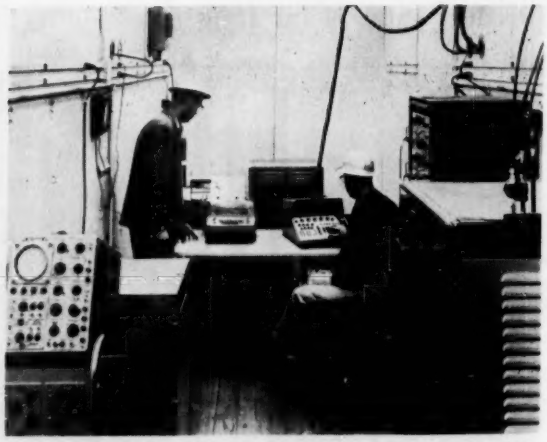
Automation has outgrown the period when it can be developed and applied in piecemeal fashion. For example, a thermometer could be replaced by an automatic temperature-recording instrument without requiring basic changes in process design or operations philosophy. When we start thinking in terms of a computer to make operating decisions and to control a process automatically, we must re-examine our practice in process design, construction operation, economics, instrument maintenance, etc. The economic implications are so far-reaching and important that we cannot leave to chance the possibility that new ideas developed piecemeal will eventually jell into the overall system we need.

It seems quite clear that advanced instrumentation and automatic control systems are inextricably interwoven with the design of the process. Heretofore, the physical and chemical designs have been frozen before the instrumentation and automatic control systems were "hung on." This reduces the potential that automatic control has to provide truly automatic operation of the process and to reduce capital investment through better design.

These processes were designed on the assumption of steady-state operation, but actual processes rarely operate at steady state. Most are continually in a condition of major or minor upset caused by numerous disturbances. The concept of steady state is beginning to give way to a dynamic concept in which steady state is only a special case. This change is accelerated by new tools and methods available for solving the complex mathematics of dynamic design.



Mobile laboratory is pulled into operating plant where, adjacent to central control room, it gathers data.—(Fig. 2)



Interior of mobile lab shows engineers at work with their advanced data-collecting equipment and computer.—(Fig.3)

Control engineers have aided this transition, since control system design is based on the dynamics of the process that it seeks to control. Thus, control engineers were probably the first to recognize the need for mathematical models of processes that include non-steady-state behavior.

Computer Control of Processes

Medium to large off-line, general-purpose digital computers are beginning to be used extensively to guide the operation of processes. When used for this purpose, they have helped to improve operations. As ever-faster calculating equipment is developed, future use of digital computers for this purpose can be expected to spiral upward. Data transmission systems are available to send information directly from plant to a centrally located computing center.

But this system is too expensive and too slow to obtain the best possible plant performance. Virtually any chemical or petroleum process is being pushed away continually from the best operating condition by disturbances that cannot be controlled. These disturbances must be dealt with in such a way as to keep the process running at maximum profit.

Fig. 1 shows the daily value of products produced by an actual process over a period of several months. The maximum product value of the period is taken as zero and the others are shown as percent below this maximum. Samples and measurements were made daily at the same hour and the product value was calculated using the best available techniques, including off-line computation. This shows how disturbances are keeping the process constantly in an unsteady condition even though best present off-line methods are being used to try to achieve the optimum performance.

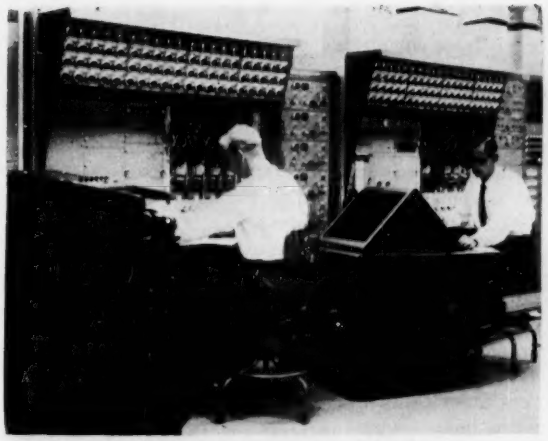
On-line computers overcome some of the disadvantages of off-line computation. Considerable effort currently is being expended in this direction. It is agreed generally that computation is going to be a mighty important part of future process control systems. Right now, there is considerable attention being given to applying medium-sized, general-purpose digital computers. The available computational hardware seems to be ahead of our ability to use it in the process industry. There are at least 15 companies that can supply digital computers for in-plant process control.

Many processors have installed computers or have indicated that they are going to. As nearly as one can tell, none of them seems ready to state that the computer is or will be a permanent piece of plant equipment. In many cases, the installation is admitted to contain a strong element of research. This does not argue against the ultimate benefit so much as it shows how difficult it really is to apply computer control.

How Computers Are Used

What is needed is systems engineering. A systems team of competent people requires up to a year to make a systems study of a process sufficiently complex to warrant digital computational equipment. It takes a lot of effort and time to train these systems teams. Everything points to the fact that a number of chemical companies have put such groups together. The evidence of this is beginning to show up in more concrete results being reported in the literature.

Meanwhile, important and somewhat more immediate results are being obtained with simpler computers. At Phillips Petroleum Co., as a result of a systems study of fractionators and systems of fractionators, we have developed and applied an analog computer to hold constant the internal reflux in a fractionation tower. In the present state of the art, it's doubtful that it would pay to use a portion of a general-purpose digital computer to achieve this result. Even if one were available in the plant, it would be too slow to satisfy the dynamic requirements of good control.



Analog computing facility is used for simulation of process problems. Output of computer is easily read curve.—(Fig. 4)

Although real-time control with a digital computer is possible, it seems impractical to solve the internal-reflux control problem in this way. It appears from information released so far that the application of digital computers has been limited to operating-guide presentation or to set-point control. This is a control system that tries to nudge the process from one steady-state position to another. It ignores much of the dynamic problem because it relies upon internal fast-acting control loops.

The evolution of complete control systems will include assorted sizes and types of computers—analog, digital, incremental, and hybrids of the three. For cost reasons, smaller computers tend to be analog, although it seems that a manufacturer is about to announce the availability of small, special-purpose digital equipment. It is evident that smaller computing devices will develop more quickly and become the forerunners of the more elaborate systems. In the evolutionary development of systems engineering, many parallel paths are possible. Different paths will be followed by different groups working in more or less the same areas. Some of them will merge or disappear or be replaced by other approaches as system research progresses.

Analog Computer Aids Systems Approach

To be effective, a systems study team must have a digital and an analog computer at hand. The digital computer can and perhaps should be a central facility. On the other hand, the analog equipment must be immediately available and operated by a systems engineer who is working on the problem. Because differential equations are easily handled on them, analog computers are especially useful for the solution of problems of reaction kinetics and process control. These problems are, in general, difficult to study on a digital computer. The advantage of the analog becomes even more pronounced when one encounters control processing systems containing nonlinear elements. Chemical and petroleum processes are characterized more often than not by nonlinear behavior. By simulation, the systems engineer can study the dynamic behavior of the system, try out new ideas and, most important of all, gain insight into the development and application of automatic control principles to physical and chemical processes. A suitable analog facility should have 150 to 300 operational amplifiers plus sufficient nonlinear equipment, such as multipliers and function generators. Fig. 4 is a photograph of an analog computing facility.

Starting a Systems Study

In all systems studies, an initial decision must be made as to the scope of the project. This decision involves setting two limits:

1. The physical boundaries of the system.
2. The relative emphasis to be placed on control of the process as designed, compared with changes in the process design, e.g., the physical equipment.

Ideally, the physical boundaries always include the entire process. However, in practice it's often evident that only a portion of the entire process can be handled practically. Again ideally, equal emphasis should be placed on control and process design. However, in an existing plant it is usually evident which approach appears more fruitful relative to the effort involved. Both approaches always will be used. The decision involves determining which should be emphasized.

Fig. 5 is a diagram of a possible process system. This could be a fractionator, a series of fractionators, a reaction plus separation; in fact, it can be any unit that it is desirable to analyze or design. It is a starting point in beginning an investigation, and it will serve to bring out some interesting ways that a systems engineer might look at a chemical or petroleum process. There are two types of inputs:

1. *Manipulated Variables.* These are ones that can be controlled such as temperature, pressure, internal recycle, steam, cooling water, catalyst, etc.
2. *Disturbance Variables.* These cannot be controlled. They include ambient or weather conditions, human error, mechanical failures, changes in feed flow or composition, etc.

The outputs from the process include material, energy and information. The material output is the product plus byproducts in terms of quantity and quality.

Three steady-state equations ordinarily are needed. These are shown in Table I as functions of typical significant variables. For accurate steady-state control, quantitative relationships are required and these are not easy to find. In some cases, it may take up to one or two man-years of effort to derive them from available theory, pilot-plant and commercial-plant data. Since the variables usually interact with each other, the significant interactions need to be determined and expressed quantitatively.

The steady-state equations would be sufficient if the

process were actually steady, but real plants are subject to disturbances that occur too frequently to permit close control in this way. Closer control means better quality, more production and more profit, and these days this profit is worth going after. To get the closer control, quantitative dynamic relationships of and between the variables are required. Some dynamic equations are shown in Table II as functions of typical significant variables. Time is the most important variable that has been added to the steady-state conditions. It's necessary to know when things happen, the rate of change of disturbances, the response of the system to changes. All important components of the system must be included.

This very much oversimplified picture will serve to show some of the considerations that must be examined. Perhaps a little additional insight will be gained by a somewhat general description of a systems study of a real process. The literature contains virtually no detailed presentations of completed systems engineering projects in the chemical process field.

A Process Systems Study

The following is a brief example of a systems study on an existing plant. The plant consists of four separate steps: feed preparation, polymerization, polymer separation and polymer finishing. In this example, the system boundaries were arbitrarily set to include only the polymerization step and a part of the feed preparation. Further, the decision was made to emphasize control of the process as it existed. No real effort was to be made to analyze possible major process changes. Inevitably, of course, the benefits of minor process changes become evident as a systems study progresses. The control aspect was emphasized by a decision to study the process in terms of on-line digital computer control.

A decision such as this limits the scope of a study. One runs the risk of missing major benefits that might occur from some other approach. On the other hand, it provides a policy guide that keeps the study aimed in a specific direction. As in all engineering, a compromise is required between the ideal but impractical study and no study at all.

Returning to our plant example, this particular process is somewhat unusual in the following ways:

1. It is a "recipe" process.
2. The effluent product must meet quality specifications with both an upper and lower limit.
3. A single product is made at a time, the amount of which is predetermined by market demand. No by-product streams are involved.
4. Because of (1), (2) and (3), there is no economic "optimum" way of running the process that varies with time.
5. Although the process is continuous, the reaction time is several hours.
6. The objective of process improvement is primarily to improve quality rather than increase capacity or reduce plant operating costs.

Because of the long time lags, conventional feedback control is difficult, and a strong feedforward control system is required. This, in turn, requires a fairly accurate description or mathematical model of the process.

In this example, the main process variables can be described as shown in the box. The modeling, in this case, consists of mathematically relating the two dependent variables with all of the independent ones. At this point, another decision is faced, namely, the relative emphasis to be placed upon model development from theoretical knowledge and empirical plant data. Although any model finally must depend upon empirical plant data for equation coefficients, it is generally true that the equation form is valid over a wider range of variables if based upon theory. For this reason, all available theoretical knowledge should be incorporated in a model.

Main process variables

Dependent variables
Extent of polymerization or conversion, C
Primary quality variable, Q
Independent variables
Temperature
Production rate
Recipe (a function of specified product)
Feed quality (impurities)
Control variables
Temperature
Recipe constituents, e.g., catalyst
Reaction time
Disturbance variables
Feed quality (known impurities)
Feed concentrations
Feed quality (unknown variations)

Building the Model

In this particular case, considerable theory is available. All steady-state equations are therefore derived on this basis. The result is then two steady-state equations relating conversion C and the quality variable Q to their respective independent variables. In functional form, these are:

$C = f(\text{recipe, temperature, feed quality})$
$Q = f(\text{recipe, feed quality})$

Another model must be devised for blending feeds to assure getting the required recipe. Several feed streams are involved in which concentrations of the desired components vary as step changes. Therefore, a set of simultaneous equations must be set up for blending these feeds to give the desired recipe. In addition, surge volumes exist between the points where feeds are analyzed and are introduced into the polymerization reactors. This imposes a further requirement on the blending model—that we account for the feedforward mixing of feeds in the surge volume. The

net result is that steady-state feed concentrations are never reached. Functionally then, we denote the blending calculation by

Recipe = f(feed stream concentrations, time)

In a similar manner, the feed quality (impurity concentrations) varies with time. Therefore, we have

Feed quality = f(feed stream impurity concentrations, time)

Having the feed quality and recipe blending equations, we can now use the two steady-state models for C and Q for feedforward compensation. That is, some recipe constituents are treated as control variables for feed compensation. In an ideal system making a single product, perfect control would result.

However, more than one product is produced and no system is ideal. To change products, the recipe is changed. To predict the product quality during the transition period, the process dynamics must be known. This requires an extension of the product quality equation to include time such that

$$Q = f(\text{recipe, feed quality, time})$$

Since the system is not ideal, temperature is also used as a secondary control variable for conversion. Conversion and reaction rate can be measured in the process. With this information, temperature can be used in a feedforward system to change reaction rate. Here again, the temperature response must be known. This requires an extension of the conversion model to include time such that

$C = f$(recipe, temperature, feed quality, time)

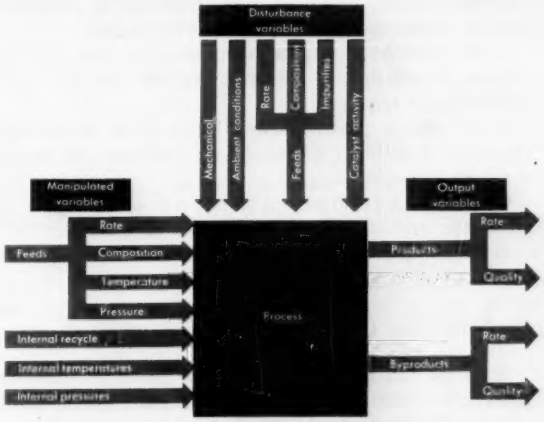
Finally, again because of the nonideal system, feedback must be employed. Direct feedback is not feasible. Instead, model updating is relied upon. Relative to process time, high-frequency variations of unknown feed quality variables are of little concern. These are damped out in the long process time. Low-frequency variations can be taken care of by feedback. But those frequencies of the same order as the process time present real problems with no simple method of dealing with them. In practice, it is these frequencies of unknown variations that limit the extent to which perfect control can be achieved.

Recasting Study and Approach

To summarize, the steps involved in this process system study are as follows:

1. Define the primary economic goal of improved quality.
2. Define the system boundaries.
3. Decide on putting primary emphasis on control of the existing process.
4. Decide on a strong feedforward control system.
5. Decide on a digital computer control system.
6. Decide on model development primarily from theoretical information.
7. Develop separate models for feed blending, feed compensation, steady-state control of dependent quality variables.
8. Extend the steady-state control models to include the process dynamics.
9. Incorporate feedback for model updating.

Generalized process block diagram—Fig. 5



Steady-state equations—Table I

Yields	= f (Disturbance and manipulated variables)
Operating costs	= f (Disturbance and manipulated variables, unit costs)
Profit	= f (Product value, operating and feed costs)

Objective: In the face of the disturbances, to maximize profit, subject to certain constraints.

Dynamic equations—Table II

Yields	= f (Steady-state costs, time, process and control-loop dynamics)
Operating costs	= f (Steady-state costs, time, process and control-loop dynamics)
Profit	= f (Dynamic product values, dynamic operating and feed costs)

Objective: In the face of the disturbances, to maximize the time integral of profit over some time period, subject to certain constraints.

A systems approach to controlling a process such as this is required because of the various fields of discipline involved. To clarify this, these disciplines can be summarized as follows:

1. Knowledge about and experience with the process is mandatory. This requires the process engineer.
2. Development of theoretical relations requires fundamental knowledge about the chemistry of the process.
3. Because processes in general never operate at a

steady state, knowledge about the effects of the process dynamics on any proposed control scheme is required. Analog simulation is almost a necessity here.

4. To include a digital computer in the control scheme, knowledge of computer capabilities and programming is required.

5. To obtain the necessary input data, knowledge about the feasibility of on-stream analyses and measurement is required.

6. Finally, a requirement common to some degree to all of the preceding is a good grasp of mathematics.

It is evident that no single academic discipline covers all of these requirements.

Experimental Commercial Plant Studies

Systems can be analyzed and designed based upon presently available theory, pilot-plant and commercial-plant data. In fact, this is probably the best way to proceed if an early answer is desired because new data are difficult to obtain. Also, the initial step in any systems study must be based on available information. It seems to be true that there is considerable information that can be used to analyze and design new processes or modify existing ones. However, this is not always the case. Modern instrumentation makes it possible to learn much more about full-scale plant performance than conventional operating instrumentation permits. The industry is especially deficient in the facts concerning the dynamic characteristics of processes.

It is becoming increasingly important, therefore, to make special experimental studies of commercial plants. A number of companies recognize this and are building mobile data collecting and analyzing laboratories for such purposes. By installing high-speed chromatographs and other continuous analyzers, data logging apparatus and computing equipment, it is possible to obtain quite complete information in a short time. The routine operation of the plant does not call for this special equipment, so it is installed in a mobile truck that can be moved from plant to plant as needed.

Figs. 2 and 3 show such a laboratory in a 35-ft. movable van. The lab contains special data-logging equipment, analyzers and a digital computer. With this particular equipment, an ethylene cracking furnace was experimentally studied. As a result of the studies, plant capacity was increased 10 percent by modifying only the operating procedures. The mobile lab was only used in the plant for a few months, without permanent installation.

Summing It Up

Systems engineering has two major objectives: designing an optimum plant, including planning the lab and pilot-plant program to obtain necessary data, and optimizing operation of an existing plant. Both of these are important but the big advances will probably be made in the design of new plants.

The discipline implies the use of advanced mathematical techniques and analog and digital computers. Too, the most advanced knowledge in chemical engineering science must be used.

Two major differences distinguish the systems approach from the conventional chemical engineering approach—a consideration of process dynamics, and analysis of the problem as a whole. The conventional concept of the steady state must give way to our knowledge that processes don't operate at the steady state. Since they operate as dynamic systems, they must be designed as dynamic systems.

Too, newness of the systems engineering approach resides in the ability to consider the process as a whole —design, operation, economics, instrumentation, control—and arrive at one, best over-all system for optimum performance. These are, of course, traditional areas of interest for the chemical engineer, and will play a big part in any systems team.

Systems engineering, concerned with complex systems, requires a highly communicative team approach. Based upon present trends, it appears that two things are happening. First, groups of highly trained specialists in systems engineering are being created. Second, this recognition of a new specialization will be accompanied by the introduction of many systems engineering techniques into all conventional areas of engineering.

One thing's certain: systems engineering evaluations will accelerate the present trend toward automation. They conform to current patterns of increasing complexity and capability of technology to meet the challenge of economic survival among the evergrowing forces of competition.

Meet the Author

THOMAS C. WHERRY *is manager of the instrumentation and automation laboratory, Research and Development Dept., at Phillips Petroleum Co., in Bartlesville, Okla.*

Responsive to the disciplines of two calls in his practice of control systems engineering, Wherry was educated in both chemical and electrical engineering. He took a bachelor of science degree in each at Kansas State College.

Prior to his current assignment in Phillips, he worked in the production and research departments, developing new geophysical instruments and designing petrochemical processes. He is the author of a number of technical papers on many aspects of process control and instrumentation, and has been active in affairs of the Instrument Society of America.

Better heat recoveries, higher pressures, higher purities mark newer process methods. An expert compares five ways to make today's in-the-news hydrogen.

Which Process Best for Producing Hydrogen?

G. R. JAMES,
Chemical Construction Corp.

Hydrogen is finding wide uses throughout industry, aside from its basic role as a raw material for ammonia and methanol. It has recently become more important in petroleum refining where previous hydrogen exporters are now making and using hydrogen in increasing quantities. Hydrogen in the direct reduction of metal ores, although still in its infancy, has a promising future. And hydrogen is considered an up-and-coming missile fuel.

Spurred by keen competition and larger markets, the chemical industry has embarked on an all-out effort to increase purity and improve efficiency of hydrogen processes by better heat recovery, higher operating pressures and better use of available materials.

Ten years ago, for example, all reforming was done at low pressure and little effort was made at heat recovery. New plants now operate at 100 to 300 psig. and every possible Btu. is squeezed out of the gases before purification. During the same ten years, new processes have been developed and installed throughout the world. Partial oxidation for the production of H_2 and CO from carbonaceous materials has been perfected by Texaco. Shell Oil and other investigators have recently announced partial-oxidation processes of their own.

No Process Panacea

All of this places great responsibility on the design engineer. Hydrogen plants ranging from 50,000 to 50,000,000 scf./day are furnishing hydrogen for a variety of industrial uses as well as for conventional manufacture of ammonia and methanol.

It would be presumptive to specify any single hydrogen process as the best—first, because of the many process steps involved; second, because of the many process alternatives en route to pure hydrogen; and third, because any chosen route will fit some requirements and not be suitable for others. For this reason, we have selected five flow schemes shown in the diagrams on pp. 162-163 as logical combinations of the several possible steps in hydrogen manufacture.

There will no doubt be disagreement about suitability of these schemes and detailed study of particular cases may show more desirable combinations. The purpose of this article is, therefore, not to recommend methods of manufacture, but to acquaint you with the various methods and their approximate costs.

These methods contain four basic steps:

- Raw hydrogen purification
- CO conversion
- CO_2 removal
- Final purification

Specific comments on the individual processes are shown under each flowsheet.

Purifying Raw Hydrogen

Natural gas is the raw material most widely used in the manufacture of hydrogen. But many plants have been designed for coke, water, heavy fuel oils, and off-gases. Perhaps the most unusual application is a plant

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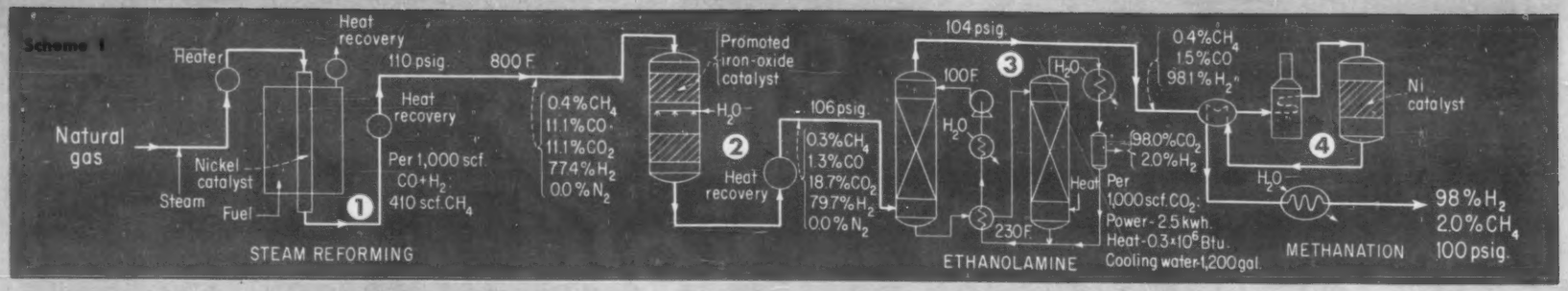

1. MAIN USES. Syn. gas for H_2, NH_3 and CH_3OH; from natural gas LPG, or off-gas. No air separation plant required. **ADVANTAGES.** Ease of operations; long operating periods. Shutdown usually only for boiler inspection. **LIMITATIONS.** Allowable stress on high-temperature reform tubes. Sulfur must be removed from feedstock. Heat loss in stack gas. **VARIATIONS.** Operating pressures from 5–250 psig. Heat recovery by several means supplies boiler feedwater, heat, CO_2 removal regeneration, other low-level heat.

2. MAIN USES. This CO conversion is used normally in conjunction with gas-reform plants. Difficulties that may arise are: overheating, consequent catalyst deactivation and catalyst plugging, due to carryover of entrained solids. Operation is helped by pressure as less catalyst volume is required to attain the same conversion. Multiple CO conversions are used where high-purity hydrogen is required. Generally, no more than three stages will be required to achieve 99.9% H_2 on a N_2- CH_4-free basis, and usually less than three stages is adequate.

3. MAIN USES. Any CO_2 removal, especially that requiring good cleanup. Combination with other systems such as carbonate where MEA does the final cleanup. **ADVANTAGES.** MEA is the favorite for removal of CO_2 to low concentrations. Low-pressure applications require its use, as do many small plants where complete removal is required. Can also be used in combination with glycols where gas drying is required. **LIMITATIONS.** Regeneration efficiency cannot approach that of carbonate because of the two temperature levels of absorption and regeneration. A large portion of the regeneration heat input is used in heating the solution after heat is recovered from the liquid leaving the regenerator. Minor foaming problems occur. The degeneration products from oxidation or other reactions must be removed. MEA loss is a reasonably costly item in plant operation. **VARIATIONS.** Materials of construction; size of exchangers; amount of heat to be used for regeneration; pressure of regeneration.

4. MAIN USES. Removal of CO and CO_2 to ppm. Handles gas containing small quantities of CO and CO_2 in presence of H_2. Easily used on any size plant. **ADVANTAGES.** Clean operation. Simplest method of CO and CO_2 cleanup. Low equipment cost and maintenance. **LIMITATIONS.** Results in CH_4 from CO and CO_2 inlet and therefore all three must be low at inlet for pure product. Temperature rise can get out of hand if inlet CO or CO_2 is allowed to climb. Nickel methanation catalyst is expensive and sensitive to sulfur and high temperature. While the methanator is simple, purification prior to methanation may be complex. For example, one to four stages of CO conversion and CO_2 removal are required for this type of purification to be combined with any of the raw H_2 processes mentioned. **VARIATIONS.** Inlet CO and CO_2 from 0.1 to 1.5%. Pressure from atmos. to 15,000 psig.

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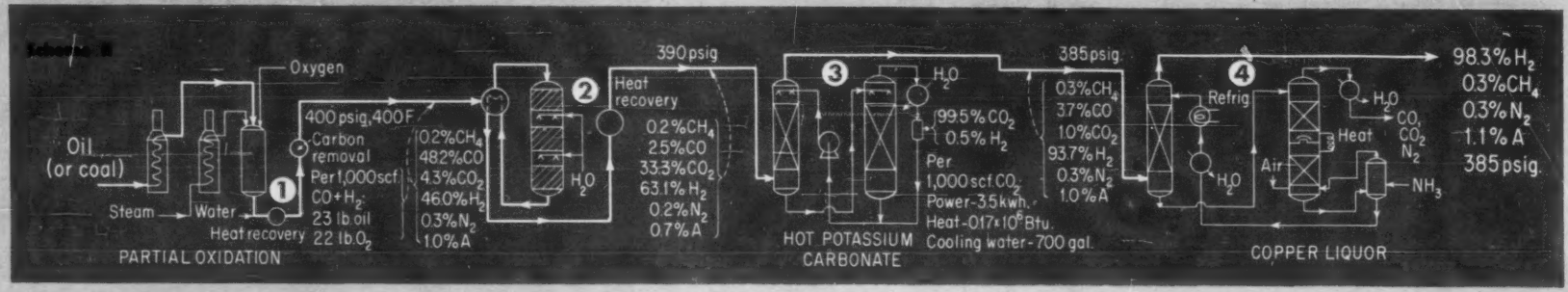
1. MAIN USES. Syn. gas for H_2, NH_3 and CH_3OH from liquid, solid or interchangeable raw materials. Pressure is not a limiting factor. **ADVANTAGES.** Sulfur-containing raw materials or easily cracked hydrocarbons may be used. Methane very low in product. **LIMITATIONS.** Carbon or ash disposal required. Air plant necessary unless high N_2 product is acceptable. Complex instrumentation. Shutdowns for maintenance of air plant. **VARIATIONS.** Operating pressures up to 600 psig. and higher are possible. The same plant may be adapted to a number of raw materials.

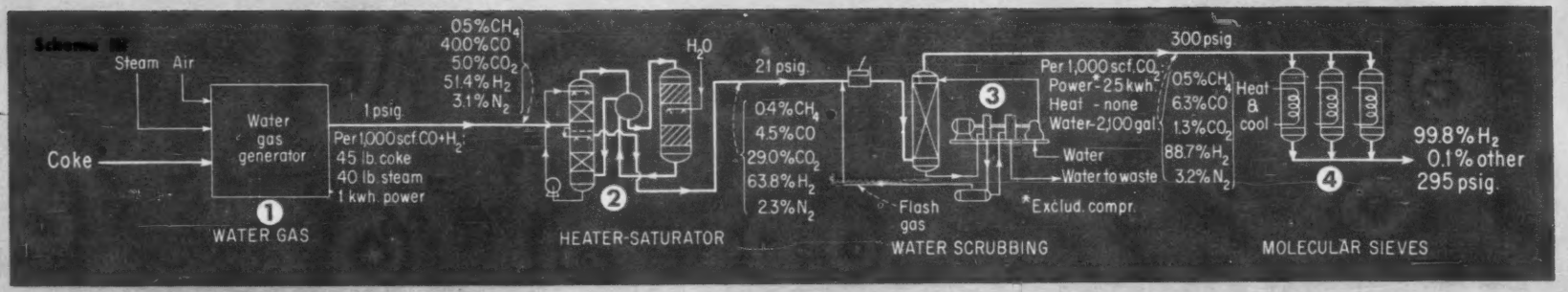
2. MAIN USES. CO conversion used with partial oxide where gases, saturated with water vapor and fairly high in CO, enter system at 400 F. Problems are similar to Scheme I, with added complications of possible carbon carryover, H_2S in gas and possible wetting of hot catalyst with quench water.

3. MAIN USES. Removal of large quantities of acid gases where residual CO_2 of 1–3% can be tolerated. Combination with other systems for effective removal of all CO_2. **ADVANTAGES.** Heat saving is main advantage over ethanolamine scrubbing, power saving over water scrubbing. Regeneration temperatures are lower than in ethanolamine, allowing use of lower-level waste heat from other sections of a plant. Material of construction in the plant is carbon steel except for a few items such as reboilers. CO_2 off-gas, where indirect heating is used, is very pure because of high pickup of CO_2 per gallon and low solubility of unreacting gases at high temperature. **LIMITATIONS.** Because of the high partial pressure of water over the hot solution, relatively high partial pressure of CO_2 over the solution, and the lower absorption coefficients and heat efficiency at consequently lower temperatures, hot potassium has been generally limited to pressures in excess of 100 psig. Sludge buildups in the system can plug equipment unless proper care is taken. Generally not efficient for removing low percentages of CO_2. Also not good on small plants where exit CO_2 must be low. Tower sizes are large for effective pickup of CO_2. **VARIATIONS.** (1) Two-stage regeneration and two-stage absorption to allow removal of residual CO_2 to less than 0.3% and still maintain operating efficiency, (2) split-stream absorption only, with the top stream cooled or cooled and diluted, (3) two-step absorption with a compression stage between steps, (4) combination of a carbonate absorption for the bulk CO_2 removal (say, to 3.0%) with MEA for final cleanup (popular with partial oxidation).

4. MAIN USES. Removal of CO or CO and CO_2 from gas at pressures of 200–5,000 psig. on reasonably large plants. **ADVANTAGES.** Gives extremely good CO and CO_2 removal with modest utility cost. Can handle CO and CO_2 in same stream and makes good combination with K_2CO_3 scrub or water scrub. Flexible operation (quick startup, easy-to-change load). **LIMITATIONS.** Corrosion sometimes a problem. Effluent toxic to marine life. Ammonia required. Impure off-gas (CO, CO_2 and N_2). **VARIATIONS.** Type of organic-acid radical used (acetate, formate or carbonate). Oxidation of Cu^+ to Cu^{++}, with CO_2 or air.



Here Are Five Schemes for



1. MAIN USES. City gas manufactured from solid fuel. NH_3 synthesis gas. **ADVANTAGES.** Good for low-pressure syn. gas applications. **LIMITATIONS.** Cumbersome equipment. High maintenance. Low-pressure operation. **VARIATIONS.** Can use several raw materials including oil.

2. MAIN USES. Used on unsaturated gases at high or low pressure. Examples are C_2H_2 off-gas, unsaturated partial oxidation off-gases, water gas. Heater saturators may be simplified by putting one tower above the other and allowing gravity flow of water from the upper to the lower.

3. MAIN USES. Where a large supply of cold water is available. Where residual CO_2 of 1 +% can be tolerated in the exit gas. **ADVANTAGES.** No heat required. No chemical makeup. **LIMITATIONS.** Cannot be used for low-pressure cleanup. H_2 loss is large because of large liquid volume used. Losses may be controlled but control by staged letdown results in higher compression costs. **VARIATIONS.** Type of power recovery. Re-use of water by air stripping.

4. MAIN USES. Separation of gases at any stage in the above systems where they are free from solid or liquid entrainment. **ADVANTAGES.** Suitable for small systems. High product purity with a minimum of prior H_2 purification. Low operating and maintenance labor. **LIMITATIONS.** Requires purging and consequent gas loss. Generally, not suitable for removing large quantities of impurities. Sieves are expensive (although rugged and have a long life). **VARIATIONS.** Means of regeneration; temperature; number of beds; cycle time.

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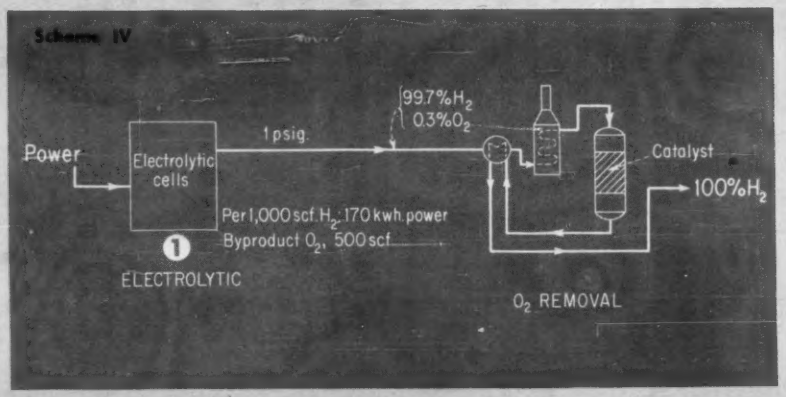
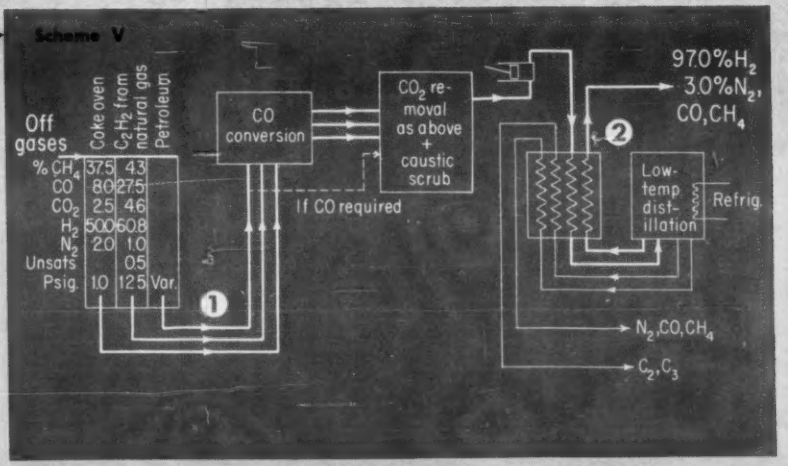
1. MAIN USES. In conjunction with caustic-chlorine manufacture. **ADVANTAGES.** Small installations for high purity. Little purification required. **LIMITATIONS.** Only can be used where power is cheap or H_2-use very small. Low-pressure gas. **VARIATIONS.** New units are coming out for high-pressure operation.

1. MAIN USES. H_2 and off-gas necessary byproduct. Used for city gas mainly, more recently for NH_3 synthesis gas. **ADVANTAGES.** Possibility of NH_3 manufacture where other raw material not available. **LIMITATIONS.** Difficult to purify. **VARIATIONS.** Hydrogen can be extracted and remainder of gases returned to steel mill; or if higher NH_3 production is required, the off-gases can be sent through a reformer, doubling NH_3 capacity.

2. MAIN USES. Purification of any H_2-containing gas after removal of impurities such as CO_2 and C_2H_2. Especially used in NH_3-synthesis gas purification in combination with an oxygen plant for partial oxidation (pure, cold N_2 provides needed N_2). Allows recovery of streams of impurities at desired purity. Important in refinery gas where C_2, C_3, C_4 fractions are valuable. **ADVANTAGES.** Can be designed to separate high-purity H_2 from wide range of gas mixtures. Clean operation with few corrosion problems and no catalyst or effluent to dispose of. Generally low maintenance. **LIMITATIONS.** Normally must be warmed up every 6–12 months for removal of solid impurities that might lead to plugging. Certain impurities such as C_2H_2 must be treated very carefully to avoid concentration. Power requirements high for refrigeration unless combined with another low-temperature plant. **VARIATIONS.** Varies with gas to be purified.





in India using junglewood as the H_2 raw material.

An important step forward in the past decade in hydrogen production has been development of partial-oxidation processes capable of operating on any hydrocarbon. These processes have freed the hydrogen producer from depending on cumbersome cyclic processes or on reforming of relatively pure natural gas. Partial oxidation has gained world-wide acceptance in less than five years. There are at least forty plants throughout the world based on partial oxidation of oil or natural gas for ammonia production or for methanol synthesis gas. Several recently completed ammonia plants in Japan and Italy, designed by Chemico, use the Texaco process operating on heavy-fuel oil or natural gas. And now low-grade coals are gasified by partial oxidation at high pressures to make hydrogen.

But electrolytic hydrogen also is making strides. Recent cells operating at high pressures supply hydrogen at 300-400 psig. with more efficient use of power and less cooling water. High-pressure electrolysis, however, has not yet been generally accepted for industrial use.

Increased pressures in reforming plants have brought large decreases in the cost of hydrogen where a high-pressure, pure gas is required. Savings are split between compression and steam costs. The higher pressures of steam-containing gases exiting from the reform system make the latent heat of a large part of the steam available for other uses such as CO_2 removal in the regeneration system. Reforming is recommended, generally, over partial oxidation, where good natural gas is available.

Converting CO to CO_2

CO converters installed in 1950 and operating on water gas or other gas at low pressure were large and cumbersome. Catalyst in use at that time had little tolerance for sulfur. New units operating at 300-400 psig. have better efficiencies compared to the old, low-pressure units, and require much less catalyst. Sulfur-containing gases are now converted at high pressure with ease, although some precautions are required in vessel design to eliminate corrosion of internals.

Removing CO_2

CO_2 removal, until recently, was accomplished with water, ethanolamines, ammonia or caustic. Now, plants use other solutions to increase efficiency. Basic carbonates, with or without various additives, have decreased heat and raw-material costs appreciably. The methods shown in the flowsheets are those commonly used in this country and throughout the world.

Variety of Purification Methods

Final purification for residual CO and CO_2 removal was handled in the past with copper liquor or low-temperature methods. A large portion of new synthesis-gas and H_2 plants are using relatively low-pressure methanation or more recently, molecular sieves. Automatic control and long service life for both reduce operating and maintenance requirements to a minimum.

A method of hydrogen purification long discussed but until recently little used is diffusion through a semipermeable substance. Hydrogen diffuses through a thin palladium-coated tube much more rapidly than other gases. By a simple one stage diffusion, relatively high-purity hydrogen can be made from impure entering gases. Recoveries are good and applications for this method of purification may be similar to molecular sieves (in small plants).

The flowsheets, with condensed comments on the various operating methods in each of the four steps, show main process uses, advantages and limitations of a particular step.

The five process discussions which follow refer to the flow schemes.

Scheme I: Steam Reforming

Reform (Scheme I) has been popular in the past few years. Preheated mixed steam and natural gas (or paraffins up through butane) pass over a nickel-containing catalyst where reaction takes place: $CH_4 + H_2O \rightarrow CO + 3H_2$. Varying quantities of steam are used—1.0 to 1.5 parts of steam to 1 part of dry gas on a volume basis in the exit gases. The reformed mixture leaving the catalytic furnace is quenched with direct water injection or in a waste-heat boiler. Generally, the majority of process steam comes from this boiler and another unit recovering heat from the furnace flue gas.

Cooled gas at 650 F. passes over a promoted-iron catalyst in CO conversion where: $CO + H_2O \rightarrow CO_2 + H_2$. An excess of steam (present in reformer exit gases) is also used here to push the reaction to the right. Further heat recovery cools the gas coming from the CO conversion, condensing some steam.

Recent pressure increases in the reform plant now allow this heat recovery step to supply a large part of the heat formerly imported for regeneration of the CO_2 removal liquid. MEA is used as the alkaline liquid for CO_2 removal and, at the pressure shown, will essentially remove all CO_2 from the gas stream. A 10-25% by weight solution of monoethanolamine absorbs CO_2 at 100 F. to 140 F., is heated and steam stripped over the temperature range 230 F. to 275 F., before heat exchange, cooling and recycle to the absorber.

Purification via Methanation

Final purification (methanation) in this flow scheme is the reform reaction in reverse:

$$CO_2 + 4\ H_2 \rightarrow CH_4 + 2\ H_2O$$
$$CO + 3\ H_2 \rightarrow CH_4 + H_2O$$

and takes place over the range 500 F. to 700 F. on a nickel catalyst. CO and CO_2 may be removed in this way to less than 10 ppm.

Normally, there will be two or three CO conversion steps to make 99.8+% hydrogen, since methanation increases CH_4 in the product to equal the CO and CO_2

in the gases going into the methanator. Where a number of CO conversion steps are undesirable, low temperature, copper liquor or molecular sieves may be more advantageous for final purification.

As plant capacity increases, there will be some reason to shift CO_2 removal to a combination of potassium carbonate scrubbing with an MEA clean-up system. Results will be a saving of up to 50% in the total heat input to the CO_2 removal section and a corresponding saving in cooling water. Capital costs for the combination are somewhat higher and operating savings must be balanced against the increased capital investment.

Operating requirements and costs for Scheme I are:

Natural gas/1,000 scf. H_2	450 scf. (no steam req'd.)
Power/1,000 scf.	2.53 kwh.
Cooling water/1,000 scf.	675 gal.
Operating labor/ 1,000 scf.	0.12 man-hr. (200,000 scf./day)
	0.050 man-hr. (100,000 scf./day)
Capital cost/1,000 scf./ day	\$1,000 (100,000 - 300,000 scf./day)
	\$450 (1,000,000 scf./day)

Scheme II: Partial Oxidation

In Scheme II, preheated steam mixed with a hydrocarbon goes to a special burner where the hydrocarbon reacts to form hydrogen and CO (C_7H_{12} [oil] + 2.80$_4$ + 2.1 H_2O → 6.3 CO + 0.7 CO_2 + 6.1 H_2).

Care must be taken to eliminate overheating the reactor when special linings are used to insulate the vessel for operating conditions up to 2,500 F. at 300 to 600 psig. Size range for a typical reactor design varies from 2 to 15-million scf./day of H_2 + CO.

Gases leave the generator at approximately 2,100 F. and are directly quenched with water or cooled in a waste-heat boiler. The flowsheet shows a direct water quench. Final heat from this quench is recovered in the regeneration of carbonate solution. A waste-heat boiler might be combined with a heater-saturator CO conversion system (see Scheme III) and water scrubbing. This would permit relatively high-pressure steam for compressor drives.

From the waste-heat boiler, or quench in this case, gases pass to a carbon removal unit which may be a direct-contact water scrub followed by some type of filter or oil scrub. The carbon plus ash extracted has so far found little use, although one process makes it available as fuel.

Different CO Conversion

CO conversion follows, using a similar catalyst to that of Scheme I. But there are important differences in CO conversion of these gases. They are relatively high in sulfur and much higher in CO than reform gases. The normal scheme involves multiple beds with water quenching of the gases intermediately. As exothermic reaction proceeds, lower temperatures and higher steam-to-dry-gas ratios are required to allow the reaction to continue. Thus, one bed will not do the job. High temperatures are used in the first bed and lower temperatures (obtained by vaporizing water into the gas steam) in subsequent beds.

Neglecting temperature effects, maximum efficiency comes with equal-size beds. Two or three beds are usual, to limit the complexity of the vessel or vessels and the intermediate quenches. Exposed materials of construction are corrosion resistant because of the high sulfur content, although internal lining of the vessel permits a carbon-steel shell.

Potassium Carbonate Removes CO_2

The next step in Scheme II is CO_2 removal by hot potassium-carbonate solution to an exit CO_2 analysis of 1%.

The system is a simple one: heat for regeneration comes from the gases exiting from the CO conversion heat exchanger. Solution circulates between absorber and regenerator with no cooling between the units. Acid gases released from this process are purer than in other systems since the hot solution does not absorb an appreciable quantity of nonreacting gas.

CO purification with ammoniacal copper (formate, acetate or carbonate) at 385 psig., as shown, is at a lower than normal pressure but will remove CO and CO_2 almost completely from the gas stream to give a pure hydrogen product except for inert gas (N_2 + A) and CH_4. Operation of this system is complex and requires careful control to avoid upsets. Corrosion, ammonia loss and the refrigeration step required have caused many manufacturers to turn to methanation for final purification. Copper liquor, properly operated and maintained, is still a competitive and useful process however, and allows production of a low-methane hydrogen without multiple CO conversion and CO_2 removal steps.

Total utilities and capital cost figures for Scheme II are:

Hydrocarbons/1,000 scf. H_2	23.0 lb.
Oxygen (95%)/1,000 scf.	22.0 lb.
Power/1,000 scf.	2 kwh.
Refrigeration/1,000 scf.	4.5 ton-hr.
Operating labor/1,000 scf.	0.036 man-hr. (2,000,000 scf./day)
	0.006 man-hr. (15,000,000 scf./day)
Capital cost/1,000 scf./ day	\$590 (2,000,000 scf./day)
	\$230 (15,000,000 scf./ day)

Scheme III: Water Gas

Water-gas production (Scheme III) is an old, well-known art. Basic reaction is C + H_2O + heat → CO + H_2. Endothermic heat is supplied by burning some of the coke in place during the air blow part of the cycle. CO and hydrogen gases normally flow to a gas holder for removal of surges between the low-pressure water-gas sets and compressor or the CO conversion step.

Compression shown on Scheme III, after CO conversion, could be placed before and result in a saving in equipment and catalysts in that section. The process would, of course, be essentially the same. CO-containing gases are heated and saturated with water in the upper section of the packed heater-saturated tower. The exothermic reaction ($CO + H_2O \rightarrow CO_2 + H_2 +$ heat) allows a wide ΔT on the heat exchanger with ΔT depending on the quantity of quench water introduced between the catalyst beds. Gases leaving the last catalyst bed give up some of their sensible heat to the entering ones and then pass to the water-heater part of the heater-saturator tower where latent heat of vaporization is converted into sensible heat.

Heat recovery is very good in this system (approaches for mass and heat transfer are very close to ideal). Some steam will normally be required between the saturator and the heat exchanger to maintain satisfactory steam for conversion.

Water Scrubbing More Economical

Water scrubbing at 300 psig. is the next step. Power requirements are not large when power is efficiently recovered from the CO_2-rich water leaving the absorber. Comparable, and in many cases better economy, result from this type of CO_2 removal compared to MEA or hot-potassium-carbonate systems.

Molecular sieves for adsorption of CO_2, CO, CO_4, and N_2 will remove these impurities to low levels with varying efficiencies depending on the temperature of the adsorbing bed. Although a single cycle unit may do the job, a probable improvement will be separate units, one for CO_2 and other gases where refrigeration will not be required for effective removal, and another for removal of those gases requiring refrigeration. This method for final purification has been confined to small installations but we have shown it here in a large plant to indicate the job that can be done on gas clean-up.

Operating requirements and costs for Scheme III are:

Coke/1,000 scf. H_2	50 lb.
Power/1,000 scf.	21.3 kwh.
Steam/1,000 scf.	340 lb.
Cooling water/1,000 scf.	643 gal.
Process water (80 F.)/1,000 scf.	1,900 gal.
Operating labor/1,000 scf.	0.03 man-hr. (2,700,000 scf./day) 0.006 man-hr. (22,000,000 scf./day)
Capital cost/1,000 scf./day	\$900 (2,700,000 scf./day) \$620 (22,000,000 scf./day)

Scheme IV: Electrolytic H_2

Electrolytic hydrogen manufacture as shown in Scheme IV will normally be limited to small installations or where power is very cheap. Larger plants will make hydrogen as a byproduct of caustic-chlorine production.

Cheap power and a market for caustic and chlorine make hydrogen by this method attractive in special locations. Because of the simplicity of the process, no detailed description will be given. Of major concern is the type of cell used to avoid large maintenance expenditures. Requirements are:

Chemicals/1,000 scf. H_2	minor
Power/1,000 scf.	180 kwh.
Cooling water/1,000 scf.	900 gal.
Operating labor/1,000 scf.	0.23 man-hr. (50,000 scf./day) 0.03 man-hr. (7,500,000 scf./day)
Capital cost/1,000 scf./day	\$3,100 (50,000 scf./day) \$1,450 (2,500,000 scf./day)

Scheme V: Off-Gas Treatments

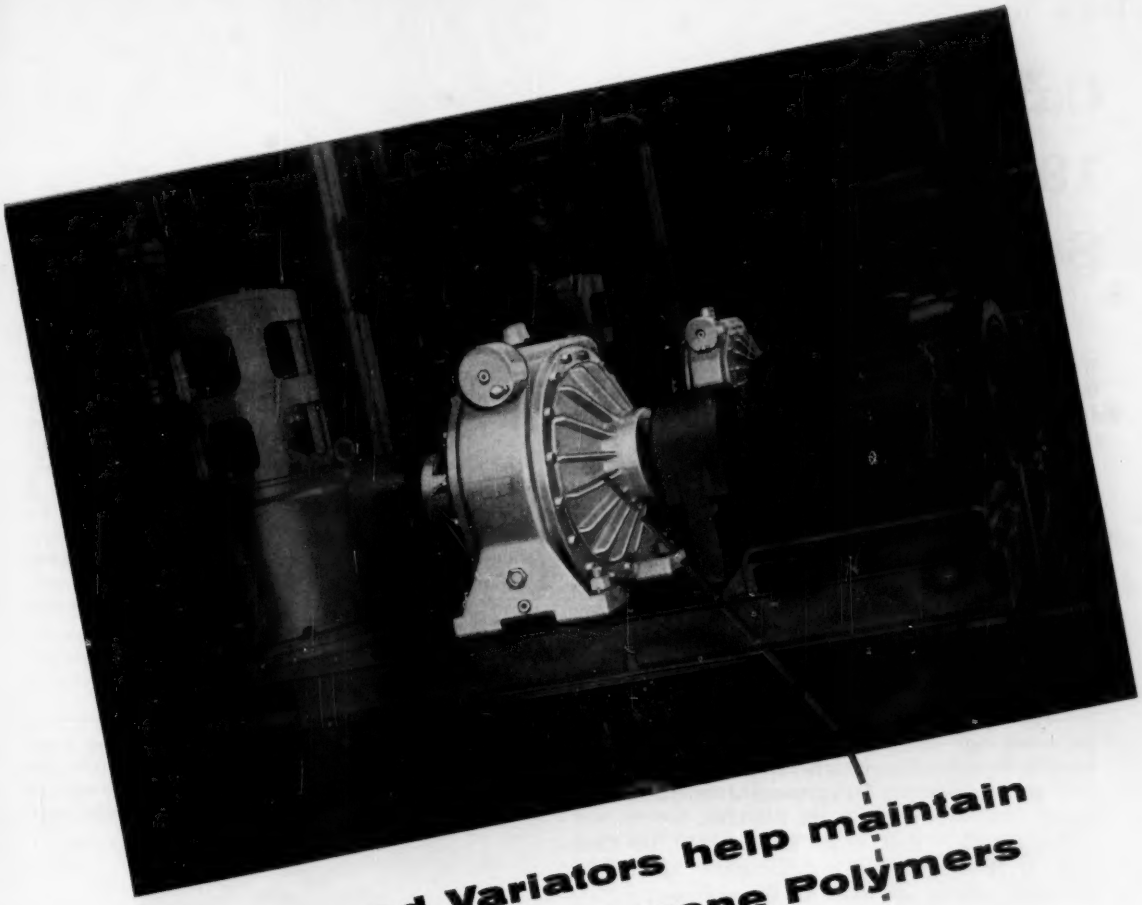
Off-gases have become an important source of hydrogen with the development of hydrogen users at plants near a source of acetylene off-gases, coke-oven gas, refinery off-gases and others. A flow scheme used with success is shown as Scheme V.

Low-temperature separation allows recovery of various fractions from the feed. In many cases, these are more valuable separately than they might be if made into hydrogen.

Partial oxidation or reform may be used for most of these gases where fractionation of the feed is not important and where maximum H_2 is required from the feed. The few gases shown are typical ones that might be treated for production of hydrogen. No operating costs will be given in this case since wide variations can occur with each feed and product requirement.

Meet the Author

G. RUSSELL JAMES *is chief engineer of the industrial projects department, Chemical Construction Corp., N.Y.C. He was the originator, designer and project engineer on the first high-pressure gas reform and hot potassium carbonate combination in the ammonia field. Ten years with Chemico, James is a PE (N. Y.) and a graduate of Yale University (B.S. in Ch.E., 1947).*



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Canada Reports 1960 Engineering Salary Data

We've acquired a copy of "Report on Salaries of Professional Engineers by Levels of Responsibility as of July 1, 1960," recently released by the Canadian Council of Professional Engineers.

Normally, the high-interest point in a report such as this would be the salary data. However, in this report we commend to your attention the excellent definitions of engineering job levels that provide the basis for the salary comparisons.

Correlating salaries against well-defined job levels is similar to the approach used by the National Society of Professional Engineers (NSPE) when it surveys its membership every two years. (Results of the 1960 NSPE survey should be available in mid-1961.) Also, the Bureau of Labor Statistics is expected to release the results of its brand-new survey of engineering salaries sometime this month. BLS is using six carefully defined job levels for purposes of comparison (see *Chem. Eng.*, Jan. 11, 1960, pp. 120-122).

Our opinion is that, at the present time, the Canadian survey succeeds best in defining the fine shades of difference among job levels in the engineering function; and that's why we've allocated the necessary space to reproduce the descriptions here.

Before you try to match yourself to a job level or to measure your own salary against the numbers given in the table, here are some things to consider:

- Salaries reported are representative of salaries actually paid in Ontario and Quebec as of July 1, 1960. On that date, the official rate of exchange pegged the Canadian dollar about 2% higher than the U. S. dollar.
- Competent industry and professional-society observers, when questioned by *CE*, estimated that the general salary level in the U. S. for engineers is anywhere from 15% to 25% higher than the going rate in Canada.

The report also makes this special point: engineers classified in a given level of responsibility vary widely in years of experience and, conversely, individuals at a given level of experience show great variance in level of attainment.

You & Your Job continues on p. 170

Classification guide . . .

	Level A	Level B
Duties and responsibilities	Receives training in various phases of office, plant, field or laboratory engineering work as classroom instruction or on-the-job assignments. Tasks assigned include: preparation of simple plans, designs, calculations, costs and bills of material in accordance with established codes, standards, drawings or other specifications. May carry out routine technical surveys or inspections and prepare reports.	Receives assignments of limited scope and complexity, usually minor phases of broader assignments. Uses a variety of standard engineering methods and techniques in solving problems. Assists more-senior engineers in carrying out technical tasks that require accuracy in calculations, completeness of data and adherence to prescribed testing, analysis, design or computation methods.
Recommendations, decisions and commitments	Few technical decisions called for and these will be of routine nature with ample precedent or clearly defined procedures for guidance.	Recommendations limited to solution of the problem rather than end results. Decisions made are normally within established guides.
Supervision received	Works under close supervision. Work is reviewed for accuracy and adequacy and conformance to prescribed procedures.	Duties are assigned with detailed oral and occasional written instructions as to methods and procedures to be followed. Results are usually reviewed in detail and technical guidance is usually available.
Leadership authority and/or supervision exercised	May assign and check work of one to five technicians or helpers.	May give technical guidance to one or two junior engineers or technicians assigned to work on a common project.
Guide to entrance qualifications	Bachelor's degree in engineering or applied science, with little or no practical experience.	Bachelor's degree in engineering or applied science, normally with two to three years of experience.
Salary ranges		
Median on July 1, 1960	$5,220	$6,240
Middle 50% spread	$4,920–$5,460	$5,880–$6,720
Middle 80% spread	$4,800–$5,820	$5,520–$7,200

. . . for engineering job levels

Level C	Level D	Level E	Level F
This is typically regarded as a fully qualified professional engineering level. Carries out responsible and varied engineering assignments requiring general familiarity with a broad field of engineering, and knowledge of reciprocal effects of the work upon other fields. Problems usually solved by use of combinations of standard procedures, modifications of standard procedures or methods developed in previous assignments. Participates in planning to achieve prescribed objectives	This is the first level of true professional supervision or of full specialization. Requires application of mature engineering knowledge in planning and conducting projects having scope for independent accomplishment and coordination of the difficult and responsible assignments. Assigned problems make it necessary to modify established guides, devise new approaches, apply existing criteria in new ways and draw conclusions from comparative situations.	Usually requires knowledge of more than one field of engineering or performance by an engineering specialist in a particular field of engineering. Participates in short- and long-range planning; makes independent decisions on work methods and procedures within an over-all program. Originality and ingenuity are required for devising practical and economical solutions to problems. May supervise large groups containing both professional and nonprofessional staff.	Usually responsible for an engineering administrative function, directing several professional or other groups engaged in interrelated engineering responsibilities; or as an engineering consultant, achieving recognition as an authority in an engineering field of major importance. Independently conceives programs and problems to be investigated. Participates in discussions that determine basic operating policies.
Makes independent studies, analyses, interpretations and conclusions. Difficult, complex or unusual matters or decisions are usually referred to more-senior authority.	Recommendations reviewed for soundness of judgment but usually accepted as technically accurate and feasible.	Makes responsible decisions, not usually subject to technical review, on all matters assigned except those involving large sums of money or long-range objectives. Takes course of action necessary to expedite the successful completion of assigned projects.	Makes responsible decisions on all matters, including the establishment of policies and expenditures of large sums of money and/or implementation of major programs, subject only to over-all policy and financial controls.
Work is not generally supervised in detail and amount of supervision varies depending upon the assignment. Usually, technical guidance is available to review work programs and to advise on unusual features.	Work is assigned in terms of objectives, relative priorities and critical areas that impinge on work of other units. Work is carried out within broad guide lines, but informed guidance is available.	Work is assigned only in terms of broad objectives to be accomplished and is reviewed for policy, soundness of approach and general effectiveness.	Receives administrative direction based on organization policies and objectives. Work is reviewed to ensure conformity to policy and coordination with other functions.
May give technical guidance to engineers of less standing, or technicians assigned to work on a common project. Supervision not a regular or continuing responsibility.	Assigns and outlines work; advises on technical problems; reviews work for technical accuracy. Supervision may call for recommendations concerning selection, training, rating and discipline of staff.	Outlines more difficult problems and methods of approach. Coordinates work programs and directs use of equipment and material. Generally makes recommendations as to the selection, training, discipline and remuneration of staff.	Reviews and evaluates technical work; selects, schedules and coordinates to attain program objectives; as an administrator, makes decisions concerning selection, training, rating, discipline and remuneration of staff.
Bachelor's degree in engineering or applied science, normally with five to eight years of related experience.	Bachelor's degree in engineering or applied science, with five to eight years of experience in the field of specialization.	Bachelor's degree in engineering or applied science, normally with 9 to 12 years of engineering and administrative experience.	Bachelor's degree in engineering or applied science, with broad engineering experience, including responsible administrative duties.
$7,500 $6,900–$7,980 $6,420–$8,700	$8,820 $8,100–$9,480 $7,620–$10,250	$10,260 $9,500–$11,220 $8,760–$12,120	$12,480 $11,100–$13,680 $9,600–$15,000

Panelist Healy's handling of a question from a *CE* editor merits applause by panelist Joe L. Parker.

TULSA PANEL PROBES PROFESSIONAL CONDUCT

When you take a new job, can you take what you know with you?

Regular readers of these columns are familiar with our interest in the subject, "Does Your Employer Own Your Knowledge?" Many of the important legal decisions concerning this question were analyzed in *Chem. Eng.*, July 28, 1959, pp. 127-130. Also, the results of a survey conducted by Engineers Joint Council on the safeguarding of trade secrets are summarized in *Chem. Eng.*, June 13, 1960, pp. 222, 224.

At the September meeting of the American Institute of Chemical Engineers, in Tulsa, a six-man panel grappled with these questions:

How much can an engineer reveal to a new employer about a process or idea developed by his former employer? Does the offer of a new job depend on revealing such information? And if it does, is there not a question of ethics affecting the new employer too?

Moderator of the panel on professional conduct was John J. McKetta of the Univ. of Texas. The panel speakers were: Scott Walker, engineering dean, Univ. of Tulsa; John J. Healy, Jr., Monsanto Chemical Co.; George Weber, editor, *The Oil and Gas Journal;* Joseph L. Parker, Catalyst & Chemicals, Inc.; and Lawrence Coleman, Allied Chemical Corp.

"What is mine and what is my employer's? That's the question you must answer," declared Coleman, using his fascinating somewhat-British speech pattern. (Coleman is general counsel for Allied and was intimately involved in the Allied vs. Dixon matter.)

"You know better than your employer, better than any judge, what you should and should not disclose. Are you able to sleep at night? This is the only test that reasonable men can apply," Coleman said. "There are legal tests and conditions, but if you can't sleep at night, you can be pretty sure you're wrong."

"There's the temptation to make a quick buck," said panelist John Healy. "Competition is keen, and our profession bears a heavy responsibility to display honor and dignity. Companies must refrain from putting temptation in the way of employees."

Coleman pointed out that, legally, an employer must keep his secret secret—with elaborate precautions and warnings to an employee on material that is secret.

Scott Walker suggested that chemical engineers should model their conduct on the high professional standards outlined in the code of ethics of AIChE.

Moderator McKetta cited as an example the pending case, in Houston's federal court, of Lummus Co. vs. chemical engineer Phillip Witt and mechanical engineer Robert Calogne (*Chem. Eng.*, Aug. 8, 1960, p. 55).

At issue: whether these engineers, now in their own consulting business, may offer their services as consultants on the construction of ethylene oxide plants using oxygen oxidation of ethylene.

CE's editors in Houston now report that a final decision has been reached in the case. The court ruling requires the engineers to return to their former employer (Lummus) all sketches and flowsheets involving the Shell Oil Co. ethylene oxide process. However, the order allows the men to use any published material, such as patents, technical articles, etc. Also, they may continue to do consulting work for any duly licensed client on the ethylene oxide process.

The pattern that seems to be emerging in all these cases is: what's in your head is yours. What's on paper may belong to your former employer.

Your chief is now an Indian

From an unexpected quarter comes a sign of the kind of professional recognition we are all seeking. Jerry McAfee, president of the American Institute of Chemical Engineers, has been adopted as an honorary member of the Osage Tribe of Indians. The ceremony took place during the recent AIChE meeting in Tulsa. No other engineering or technical society has ever been honored in this way. The tribal council resolution places great emphasis on the particular contribution of engineers and scientists to the progress and security of the United States.

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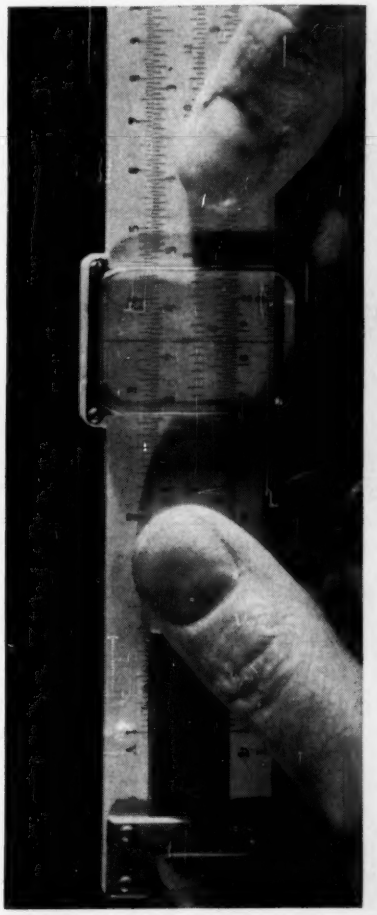

For more information on chemicals mentioned on this page, check here:

☐ Benzoyl Chloride Data Sheet ☐ Caustic Soda Buyer's Guide
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No. 46: COST-CAPACITY DATA

Although investment costs for chemical plants often follow an exponential relationship with capacity, only a dollars-per-annual-ton figure is usually quoted. Cost-capacity curves give better information.

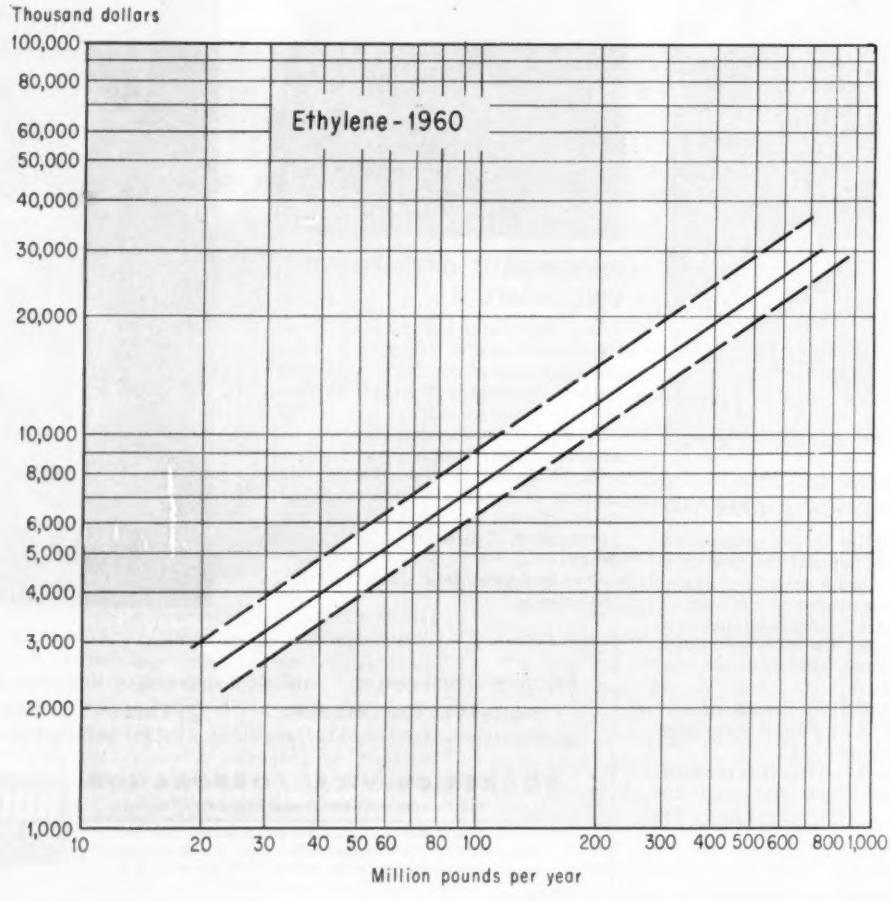
JONAS M. BERK, JOHN E. HASELBARTH
Houston, Tex.

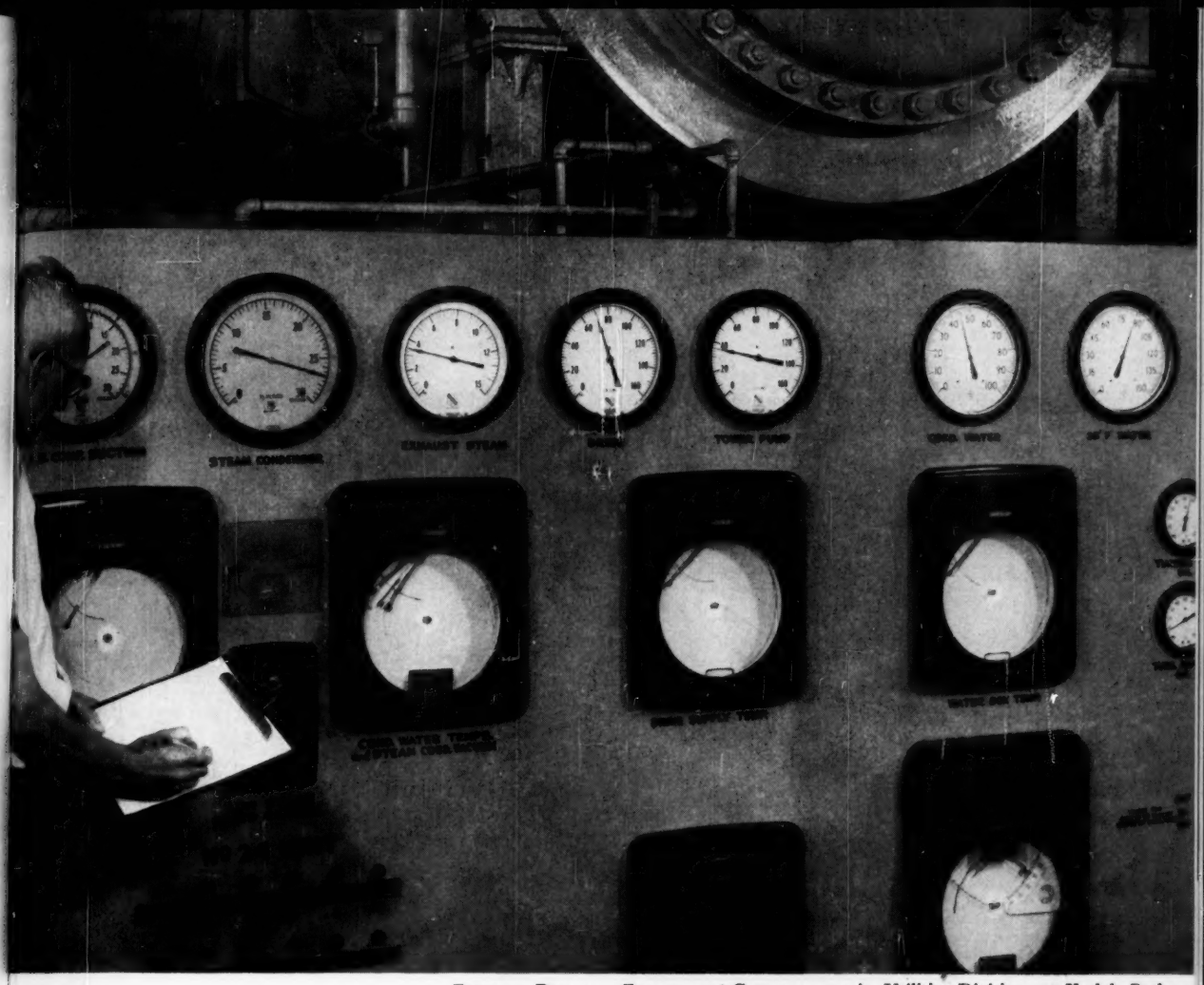
In Cost File No. 29 (Apr. 18, '60, p. 194), we examined investment costs for an ethylene plant. Assuming a given production rate, we showed how differences in definition of project boundaries affect investment cost per annual production unit.

For manufacture of ethylene from refinery gases, we said that a capacity power factor of 0.7 is appropriate. A further link between "dollars per annual ton" and the capacity factor will be shown here.

We have plotted investment cost-plant capacity data from nearly 150 private and literature sources for various chemical processes over wide production ranges. Where sufficient information has been available, the low and high limits to be expected are shown. These limits follow, in general, the categories mentioned in Cost File No. 29.

We present here data for ethylene and high- and low-pressure polyethylene. Capacity power factors (see *Chem. Eng.*, Mar. 7, '60 p. 116) for these processes are, respectively, 0.71, 0.67 and 0.90. Data are as of third quarter, 1960. Future Cost Files will contain similar correlations for other processes.





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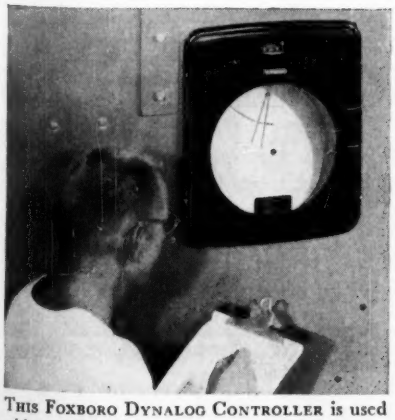
motor load – conductivity – pH – capacitance... Eastman Kodak uses Foxboro Electronic Dynalogs for dependable measurement and control



THIS FOXBORO DYNALOG CONTROLLER is used with a 1/10-inch Foxboro Magnetic Flow Meter to control flow of an additive to Kodak's paper machines at 0.1 gpm.

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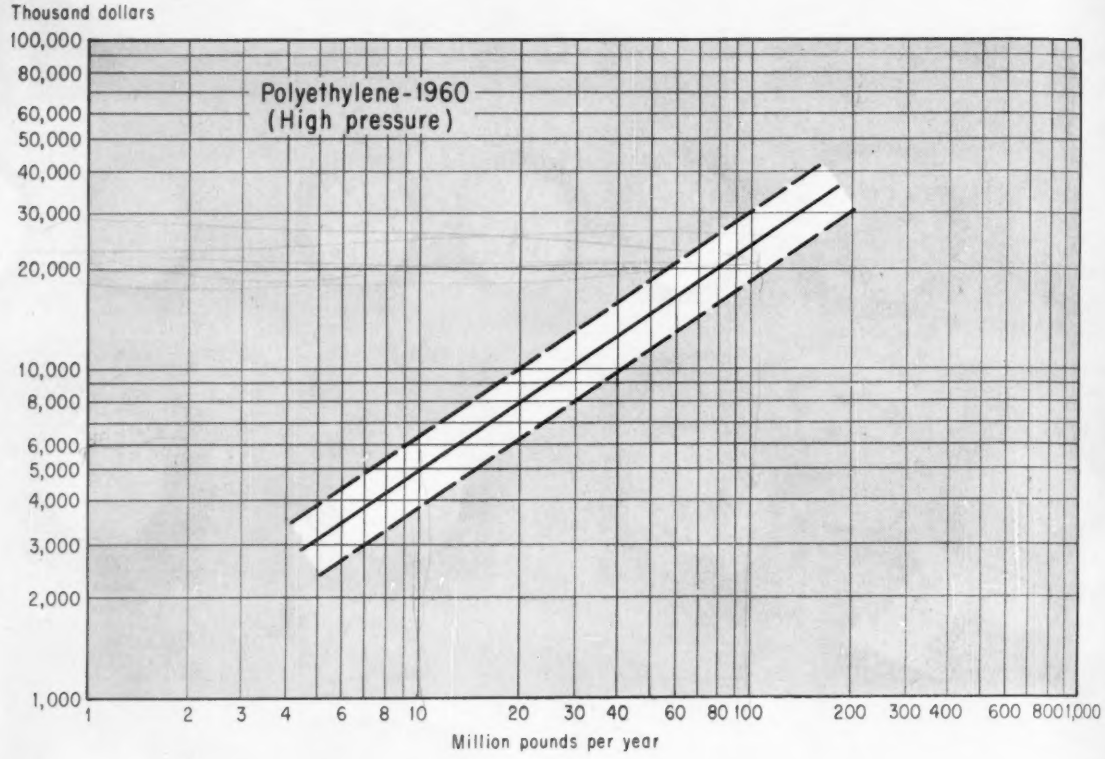
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(High pressure)
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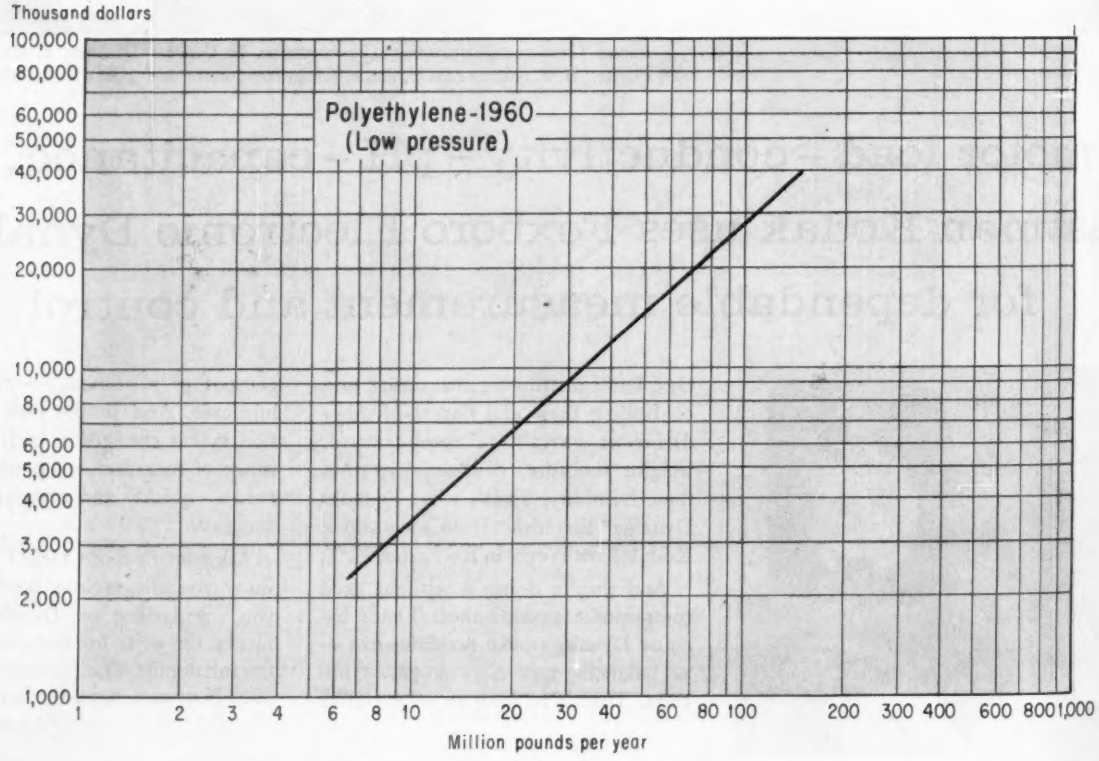
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(Low pressure)
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400
600
800
1,000
Million pounds per year

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Acidity as Acetic Acid (Wt. Per Cent)	max. .001
Color (Pt—Co)	max. 10
Water (Wt. Per Cent)	max. 0.10
Carbonyl Number (Mg KOH/g)	max. 0.2
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Initial	min. 149
Dry Point	max. 158
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Nomograph Gives Pump Horsepower

SIDNEY KATELL and PAUL WELLMAN, *Bureau of Mines, Dept. of the Interior*

One calculation commonly required of chemical engineers in research, design or development is the sizing of pumps. To aid in this calculation, the Bureau of Mines has prepared the nomograph shown below. This chart is an outgrowth of cost studies connected with coal-processing methods.

The nomograph represents the solution of the following equations:

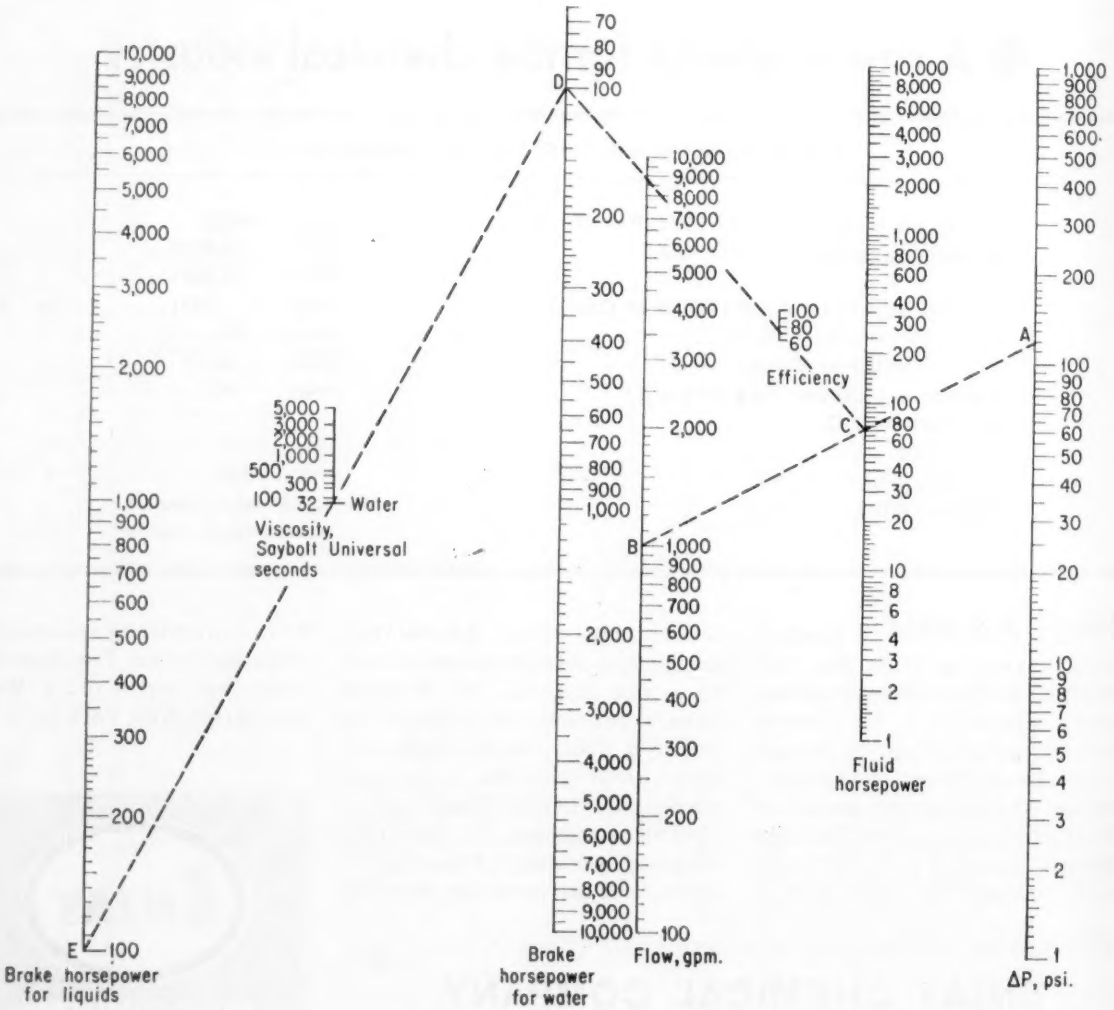
$$\text{Fluid horsepower} = \frac{\text{gpm.} \times \Delta p}{1{,}713} \quad (1)$$

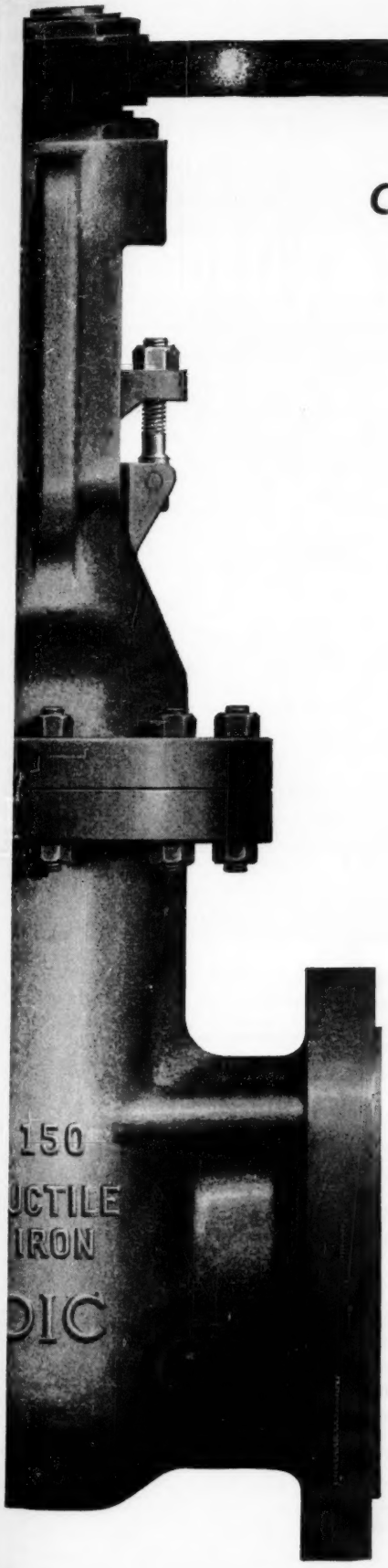
$$\text{Brake horsepower} = \frac{\text{fluid horsepower}}{\text{efficiency}} \quad (2)$$

where gpm. is the flow of fluid in gallons per min. and Δp is the head in psi.

The fluid horsepower equation is valid for pumping any liquid. For liquids other than water, the change in specific gravity or density is accounted for by determining total head in psi.

The performance rating of pumps usually includes the following three efficiency allowances: (1) hydraulic efficiency; (2) volumetric





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efficiency; (3) mechanical efficiency. Hydraulic efficiency is defined as the ratio of the power supplied by the pump to the power delivered by the impeller. Volumetric efficiency is the ratio of the volume delivered by the pump per unit time to the volume that passes through the impeller per unit time. It follows, then, that mechanical efficiency is the ratio of power supplied to the shaft to power delivered by the impeller. The efficiency line on the nomograph represents the over-all efficiency of the prime mover required for the particular service under investigation.

The single physical property of a liquid that would most cause a deviation from these calculations is viscosity. An increase in viscosity results in considerable drag on the impeller and the liquid is more reluctant to flow. This factor, the viscosity line (expressed as Saybolt Universal Seconds), correlates increased viscosity and brake horsepower with water as the base. Actually, the viscosity must be determined at the temperature at which the fluid is to be pumped, because the efficiency and consequently the horsepower are affected by the interrelationship of viscosity and temperature.

Use of the nomograph is illustrated for a pump designed to pump water at 68 F. against a head of 120 psi., with an efficiency of 70%. The brake horsepower is determined by carrying out the following steps:

1. Join the points on the Δp and gpm. scales with line AB. The fluid horsepower is determined at point C where line AB crosses the scale.

2. Then, drawing line CD from point C through the efficiency curve at 70% gives point D on the brake horsepower curve for water.

3. The line from point D through the viscosity scale at 32 SSU (water at 68 F.) gives the final brake horsepower at point E.

COMING DECEMBER 26:

Constant Rate Lab Feeder Can Be Adapted to Plant

By C. F. A. Roberts

Winner of the Oct. Contest

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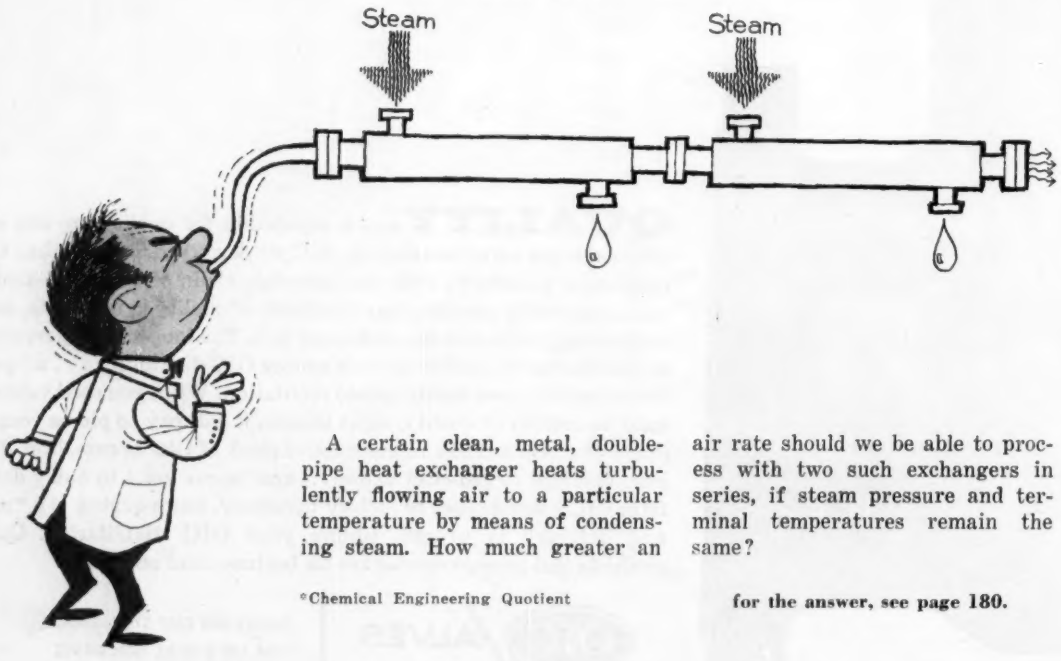
Articles should interest chemical engineers in development design or production. They may deal with useful methods, data, calculations. Address Plant & Process Design Notebooks, *Chemical Engineering*, 330 W. 42 St., New York 36, N. Y.

TEST YOUR CEQ*

ROBERT LEMLICH

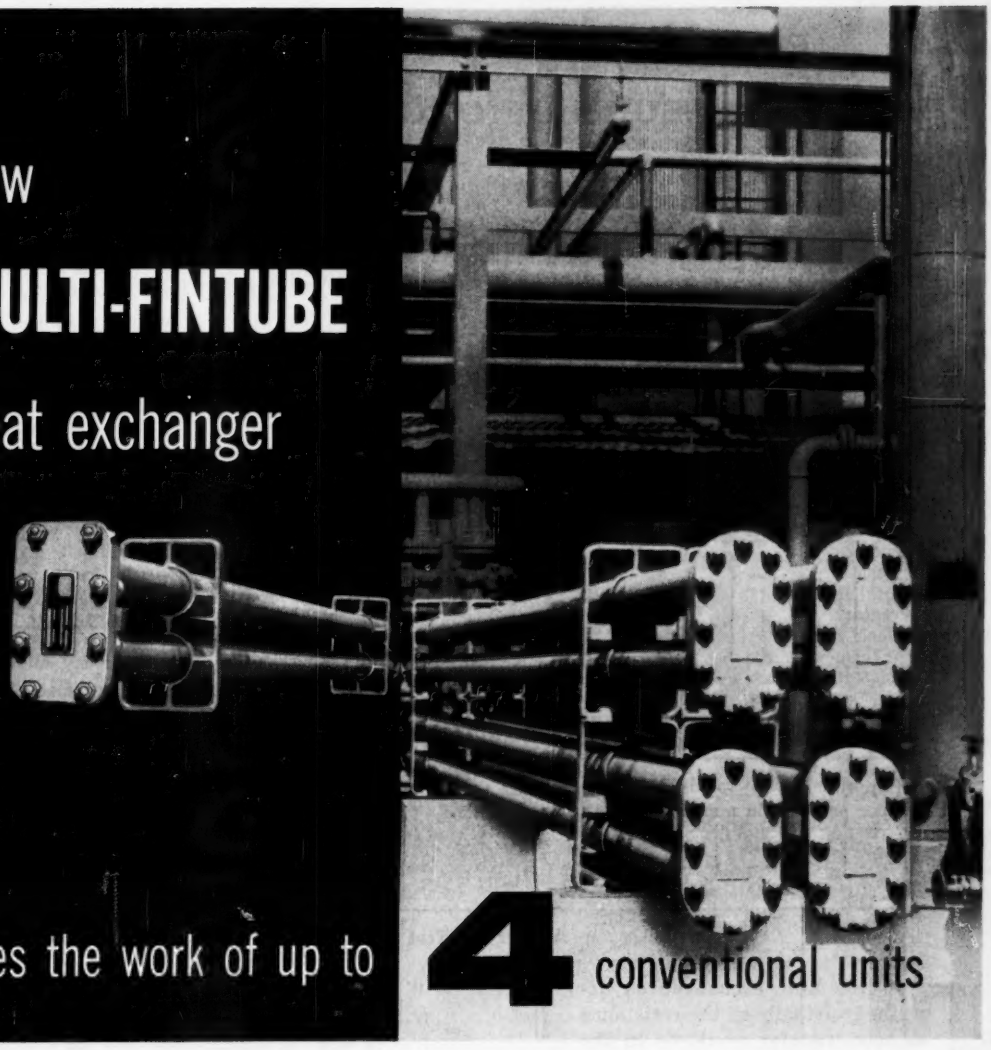


A certain clean, metal, double-pipe heat exchanger heats turbulently flowing air to a particular temperature by means of condensing steam. How much greater an air rate should we be able to process with two such exchangers in series, if steam pressure and terminal temperatures remain the same?

*Chemical Engineering Quotient

for the answer, see page 180.

1 new MULTI-FINTUBE heat exchanger



does the work of up to **4** conventional units

One new Brown multi-fintube heat exchanger has as much capacity as up to four conventional double pipe sections! Use of a bundle of finned tubes in each section ups heat transfer capacity substantially, permits standardized sections to be used for scores of additional duties, previously considered impractical or not economical. Further important cost savings are achieved by high fin efficiency factors, which makes this the ideal exchanger for light fluids such as light hydrocarbon products, chemicals and even water to water service! Obtain heat transfer savings of up to 50% or more. Investigate these cost-slashing units today.

Write for Bulletin 111 on Brown's new multi-fintube units. Address Dept. CE-12, Brown Fintube Company, 300 Huron Street, Elyria, Ohio.

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Brown multi-fintube units permit true heat exchanger standardization. The proper quantity of the same identical unit may be used in banks to meet any given duty.

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- **NO OBSOLESCENCE**—As duties change, units are used in new banks.
- **EASIER MAINTENANCE**—Only one type to service.
- **LOW PARTS COSTS**—Only four parts for hundreds of exchangers.
- **NO DOWNTIME**—Valving permits any unit to be serviced while others operate.
- **STANDBYS READILY AVAILABLE**—One unit serves as a standby.
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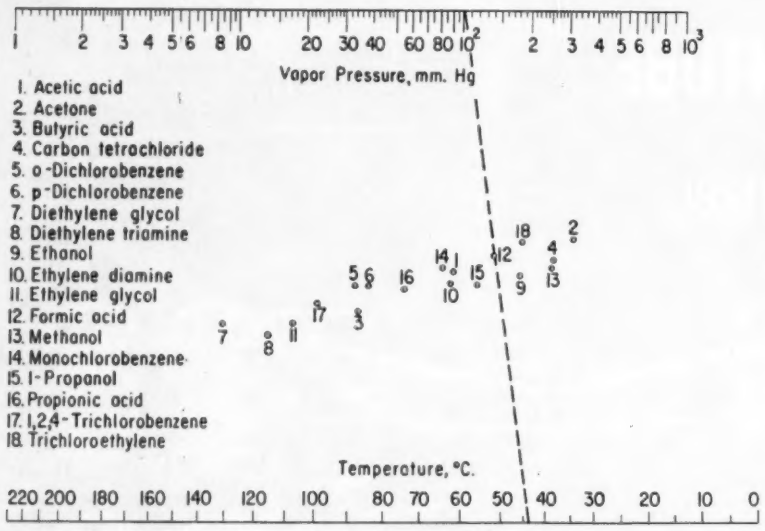
VAPOR PRESSURE OF ORGANICS

W. SHULMAN
Baltimore, Md.


1 2 3 4 5 6 8 10 20 30 40 60 80 10² 2 3 4 5 6 8 10³
Vapor Pressure, mm. Hg
1. Acetic acid
2. Acetone
3. Butyric acid
4. Carbon tetrachloride
5. o-Dichlorobenzene
6. p-Dichlorobenzene
7. Diethylene glycol
8. Diethylene triamine
9. Ethanol
10. Ethylene diamine
11. Ethylene glycol
12. Formic acid
13. Methanol
14. Monochlorobenzene
15. I-Propanol
16. Propionic acid
17. 1,2,4-Trichlorobenzene
18. Trichloroethylene
Temperature, °C.
220 200 180 160 140 120 100 80 70 60 50 40 30 20 10 0

Align appropriate dot for desired chemical with the temperature scale and read the vapor pressure in mm. Hg from the upper scale.

This nomograph permits estimation of the vapor pressure of 18 organic chemicals of industrial importance. The values are correlated from the equation

$$\log p = A + \frac{B}{(t + 273)}$$

where p is the vapor pressure in mm. Hg; A and B are constants depending on the compound; t is the temperature in °C.

For example, to find the vapor pressure of formic acid at 44 C., align point 12 with 44 C. and read 100 mm. on the vapor-pressure scale.

References

1. "Chlorinated Benzenes" and "Ethylene Amines," The Dow Chemical Co., Midland, Mich.
2. "Bulletin 44A," Hooker Chemical Corp., Niagara Falls, N. Y.
3. "Ethylene Glycol Technical Bulletin," Jefferson Chemical Co., Houston, Tex.
4. "Handbook of Chemistry and Physics," 36th ed., Chemical Rubber Publishing Co., Cleveland.

Answer to "Test Your CEQ", page 178

In the heat exchanger as described, virtually all the resistance to heat transfer would be in the air film. We can say, therefore, $U = h$. Substituting this in the usual

$$q = UA\Delta t_m \quad (1)$$

we have $$Wc\Delta t = h\,(\pi\, DL)\,\Delta t_m \quad (2)$$

Since c, Δt, D and Δt_m are the same for one exchanger as for the two together, we can simplify Eq. 2 to

$$W \propto hL \quad (3)$$

Now, the Dittus-Boelter equation states

$$Nu = 0.023\ Re^{0.8}\ Pr^{0.4} \quad (4)$$

From Eq. 4, we can say

$$h \propto W^{0.8} \quad (5)$$

since diameter and physical properties are also constant in our problem. Substituting (5) in (3), yields

$$W \propto W^{0.8} L \quad (6)$$

$$\text{or } W^{0.2} \propto L \quad (7)$$

$$\text{or } W \propto L^5 \quad (8)$$

$$\text{or } \frac{W_2}{W_1} = \left(\frac{L_2}{L_1}\right)^5 \quad (9)$$

Thus, the flow-rate ratio equals the length ratio raised to the 5th power!

For the numbers in our particular problem,

$$\frac{W_2}{W_1} = \left(\frac{2}{1}\right)^5 = 32$$

The two exchangers in series can process 32 times as much air as the single exchanger!

Of course, before actually trying this doubling up of heat exchangers, a little calculation of the increase in pressure drop is in order. Taking as an approximate friction factor $f \propto W^{-1/5}$ we have, from the Fanning equation,

$$\Delta P \propto W^{-1/5} W^2 L \quad (10)$$

or, from (8)

$$\Delta P \propto L^{-1} L^{10} L \quad (11)$$

$$\text{or } \Delta P \propto L^{10} \quad (12)$$

For a doubled length,

$$\frac{\Delta P_2}{\Delta P_1} = \left(\frac{2}{1}\right)^{10} = 1024$$

which is more than a thousandfold increase in the exchanger pressure drop!

However, if we only wish to double the air rate through the exchanger, rather than multiply it by 32, then, by (7),

$$\frac{L_2}{L_1} = \left(\frac{W_2}{W_1}\right)^{0.2} = 2^{0.2} = 1.15$$

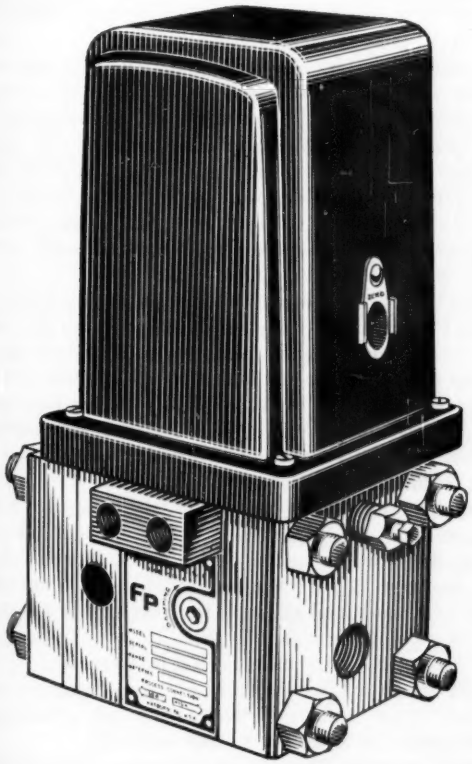
and, by (11) and (7),

$$\frac{\Delta P_2}{\Delta P_1} = \left(\frac{L_2}{L_1}\right)^{10} = \left(\frac{W_2}{W_1}\right)^2$$

$$= \left(\frac{2}{1}\right)^2 = 4$$

Thus, to double the air rate, we need a 15% greater length for our heat exchanger and must suffer four times the pressure drop through it.

■ This DP Transmitter is as close as anyone has come to the perfect process instrument. It performs every function a differential pressure transmitter *can* perform . . . dependably and competently. Every potential of an elegant and original design has been realized in the manufactured product. For example: adjustable damping in the differential sensing system lets you measure pulsating flow without zero shift, phantom signals, diaphragm fatigue, or premature part failure. A sealed measuring chamber filled with silicone oil is positively isolated from destructive process fluids. And the entire instrument is ruggedly constructed to take a beating and remain accurate and responsive. This, then, is an instrument you can install and forget. It has yet to betray a user's confidence.



Every fact you could desire about our DP transmitter can be found within the covers of our Catalog 10B1465. But nothing can ever take the place of an actual field trial. We'll gladly arrange one for you.

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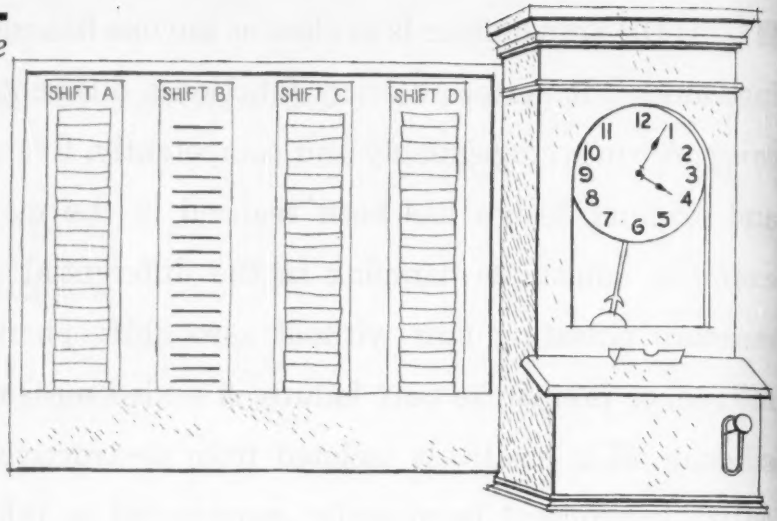


Devising equitable schedules for shift operators can be a knotty problem—you can't satisfy everyone. But this article can help you to try to do your best for your company and your personnel.

How to Set Up Operator Shift Schedules

RALPH H. WING, *West Virginia Institute of Technology*

One of the problems in maintaining satisfactory plant operation is proper scheduling of working hours for production personnel. But this is not generally considered a technical problem. Little time and attention have been devoted to it, with the result that schedules are often set up on a hit-or-miss basis.

A poor schedule can be a real source of employee dissatisfaction and a constant supervisory problem.

From the employees' point of view, working schedules should meet the following requirements:

1. Regularity. Since most people do some planning ahead for their personal activities, it is disconcerting, to say the least, to have such plans disrupted. People want to know their working hours in advance.

2. Equal treatment. Each man wants his share of the desirable Saturdays and Sundays off but no more than his share of the second and third shifts. If there is overtime involved, he wants his share of that, too.

From the employer's point of view, the work schedule must provide:

1. Sufficient personnel for the work at all times, but no more than necessary.

2. Minimum overtime.

3. Maximum employee satisfaction.

The first step in setting up a schedule is to provide yourself with a worksheet. This can be conveniently prepared on a large sheet of paper, ruled with four or five lines to the inch. Vertical lines are ruled in to provide three spaces in each column (four, if you are working a six-hour shift). The ruling for the seventh day can be accented if you wish to keep either the calendar week or the pay week clearly defined. Columns should be numbered consecutively and the days of the week marked in. The horizontal lines then indicate the days and shifts worked for each operator or each shift crew, or for the requirements of each operation.

► **Forty-Hour Week Most Common**—We will first discuss the eight-hour day, five-day week since this is most common. In one week, there are three shifts per day for seven days, or twenty-one shifts. With each operator working five shifts per week, we would require $21 \div 5 = 4\frac{1}{5}$ men.

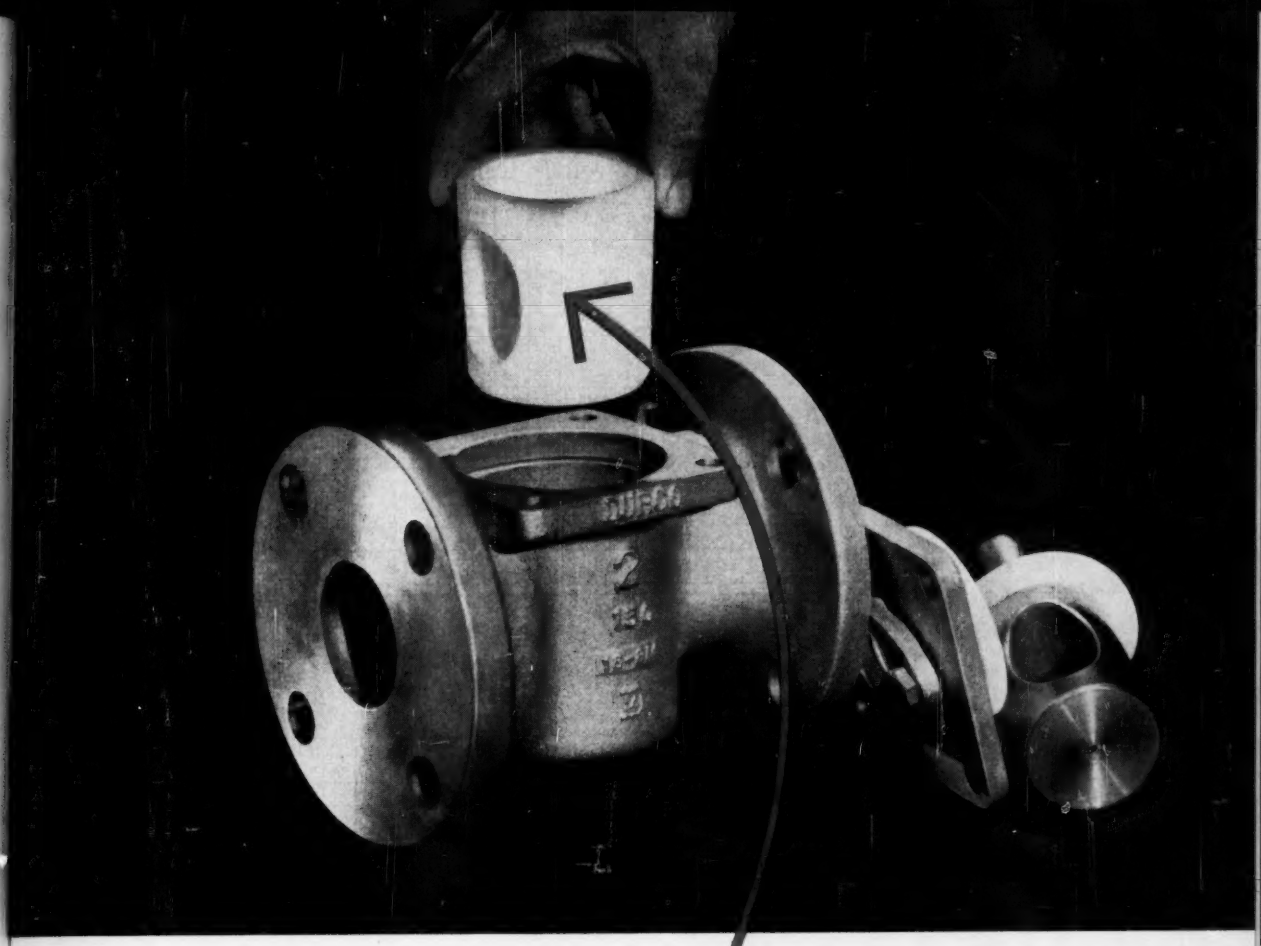
If your operations are such that you can use five men with identical skills on each shift, you can work out a schedule for 21 men with each man working a 40-hr. week. In most cases, however, you will need only one or perhaps two men with identical skills for each shift. In this case, one operator each week will work a six-day week to cover for the 1/5 man. This corresponds to an average 42-hr. week, usually with 43 hr. of pay.

In making up the work sheet, start by marking off the days not worked for each man. In this case, you have three men working five days and off two days, and one man working six days and off one day. Thus, on Fig. 1, we mark operator A off on Sunday and Monday, operator B off on Tuesday and Wednesday, operator C off on Thursday and Friday and operator D off on Saturday.

Now, mark in the shifts worked with operator A on the first shift for the first five-day period, on the second shift for the second period and so forth. Then start operator B with the second shift on Thursday of the first week and mark in the rest of his schedule from this point, rotating the shift (always in the forward direction) after each period of days off.

Start operator C on the third shift on Saturday and operator D on Sunday of the first week. This procedure keeps all shifts in proper sequence.

► **Schedule Out of Phase With Calendar**—The scheme we just discussed has two serious defects: each operator has the same day off each week, week after week;



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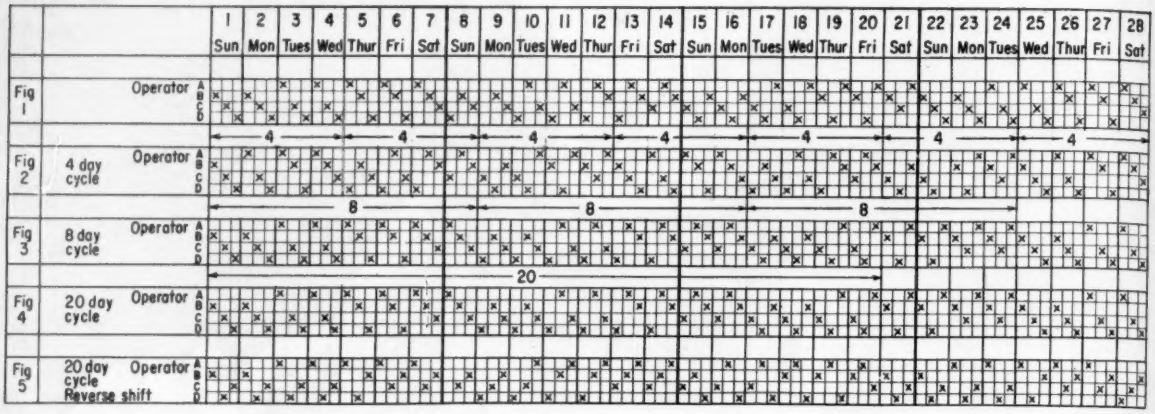
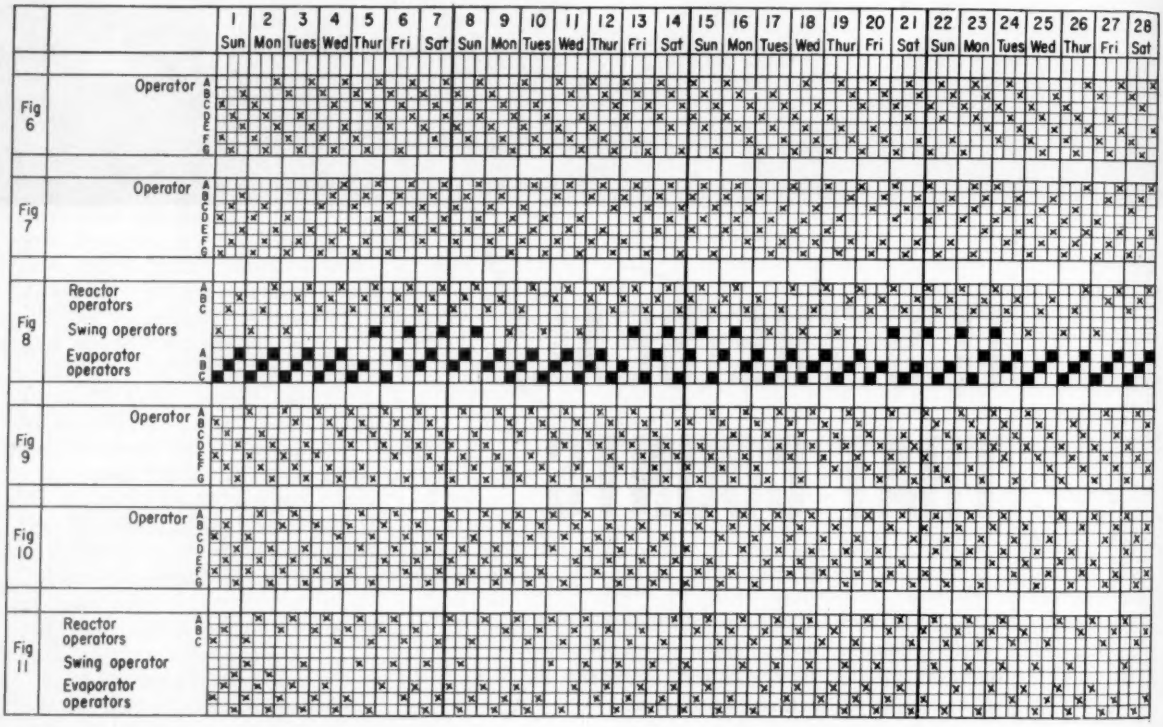
Scheduling a Five Day Week Is Relatively Easy


1 Sun 2 Mon 3 Tues 4 Wed 5 Thur 6 Fri 7 Sat 8 Sun 9 Mon 10 Tues 11 Wed 12 Thur 13 Fri 14 Sat 15 Sun 16 Mon 17 Tues 18 Wed 19 Thur 20 Fri 21 Sat 22 Sun 23 Mon 24 Tues 25 Wed 26 Thur 27 Fri 28 Sat
Fig 1
Operator A B C D
4
Fig 2
4 day cycle
Operator A B C D
8
Fig 3
8 day cycle
Operator A B C D
20
Fig 4
20 day cycle
Operator A B C D
Fig 5
20 day cycle Reverse shift
Operator A B C D

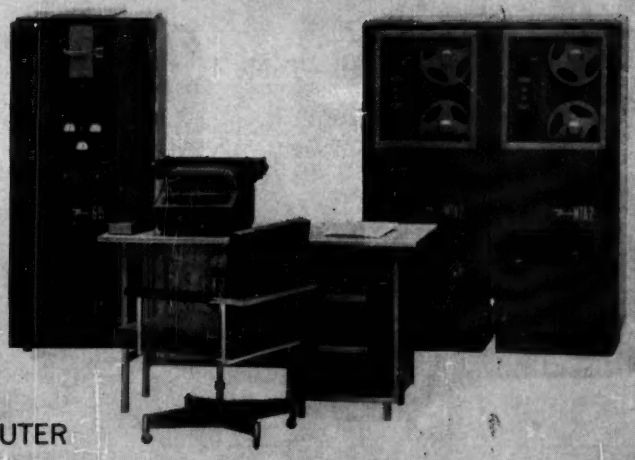
Six Day Work Weeks Create Additional Problems


1 Sun 2 Mon 3 Tues 4 Wed 5 Thur 6 Fri 7 Sat 8 Sun 9 Mon 10 Tues 11 Wed 12 Thur 13 Fri 14 Sat 15 Sun 16 Mon 17 Tues 18 Wed 19 Thur 20 Fri 21 Sat 22 Sun 23 Mon 24 Tues 25 Wed 26 Thur 27 Fri 28 Sat
Fig 6
Operator A B C D E F G
Fig 7
Operator A B C D E F G
Fig 8
Reactor operators A B C
Swing operators
Evaporator operators A B C
Fig 9
Operator A B C D E F G
Fig 10
Operator A B C D E F G
Fig 11
Reactor operators A B C
Swing operator
Evaporator operators

and one operator always gets the six-day week. To avoid this situation, the schedule must operate on a cycle that is out of phase with the calendar week.

Since there are four men working and three shifts per day, the minimum cycle possible would be $3 \times 4 = 12$ shifts, or four days. Fig. 2 shows this schedule. Each man works exactly the same schedule so that, in normal rotation, each would get the same days off and each gets his turn at the six-day week. However, the cycle is too short—one day off out of four is not as satisfactory as two days off in eight. So we must consider cycles that are multiples of the 12-shift or four-day cycle.

Fig. 3 shows the first multiple, an eight-day cycle. This is a convenient one in that each man works six days followed by two days off. You will note that although each man works six days in a row, only one man works six days in any period of seven days so



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PROBLEM: $$I = \frac{E}{\sqrt{R^2 + (6.2832\,FL - 1/6.2832\,FC)^2}}$$

(For values of R F & L as specified. For values of E ranging from 100 to 300 in increments of 50. For values of C ranging from .00002 to .000021 in increments of .0000001)

COMPLETE ALGO PROGRAM:

```
BEGIN ⓢ
R = 10 ⓢ
F = 60 ⓢ
L = ₀2 ⓢ
FOR E = 100(50)300 BEGIN ⓢ
FOR C = ₀00002(₀0000001)₀000021 BEGIN ⓢ
I = E/SQRT(R ↑ 2 + (6₀2832 * F * L — (1/(6₀2832 * F * C))) ↑ 2) ⓢ
PRINT (FL) = E ⓢ
PRINT (FL) = C ⓢ
PRINT (FL) = I ⓢ
```

Write on your letterhead for the self-teaching ALGO manual.

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THE Bendix CORPORATION

Shifts in a Nutshell—Table I

Days	Shifts	Shifts Worked/ Man	Shifts Off/ Man	Distribution Shifts Worked	Shifts Off
4	12	3	1	3	1
8	24	6	2	6	2
12	36	9	3	4–5	2–1
16	48	12	4	6–6	2–2
20	60	15	5	5–5–5	2–2–1
24	72	18	6	6–6–6	2–2–2
28	84	21	7	6–5–5–5	1–2–2–2
32	96	24	8	6–6–6–6	2–2–2–2
				5–5–5–5–4	2–2–2–1–1
36	108	27	9	6–6–5–5–5	2–2–2–2–1
40	120	30	10	6–6–6–6–6	2–2–2–2–2
				5–5–5–5–5–6	2–2–2–2–2–1–1

that, as far as the pay week or calendar week is concerned, you still have three men working a five-day week and one working six days.

If you want to reduce the working period to five days, you can consider longer cycles. A twelve-day cycle has nine working days with three days off. The nine working days can be divided into alternating four- and five-day periods, but then the days off must be split into a one- and a two-day period. To be sure of a minimum of five days worked in any period of seven days, the four-day work period must be preceded and followed by a single day off. This is not possible. Thus, the total payroll would require payment for two six-day weeks in each period of seven days and one man would work only a four-day week.

The next cycle has 20 days, with 15 working days and five days off. This cycle divides easily into three five-day working periods and three off-time periods of two, two and one day. Fig. 4 shows this schedule.

We can develop schedules with longer cycles, using the same procedures outlined above.

There is one feature of the longer cycles that we should point out. In general, each man gets the same days off each week throughout the cycle, the change in days off coming at the end of the cycle. For example, a 40-day cycle would have 30 work days and 10 days off, the working days divided into six periods of five days each. The 10 days off, which must also be divided into six periods, would then provide two-two-two-two-one-one days off in each of the six periods. Therefore, each man would have the same day off for six weeks with an extra day adjacent to his day off for four weeks. Then the schedule of days would change.

In these schedules, we have assumed that the shifts rotate in a forward direction, i.e. a man works the first shift for one period, the second for the next period, the third for the next and then starts over with the first shift in the fourth working period. A day off, for a man working regularly on one shift, means three shifts off (ie., the day off) plus two shifts off on one of the days worked. In the rotation of shifts, a worker would get a day off plus the two shifts plus an extra shift for two off-periods, then a day off plus two shifts, minus two shifts.

▶**Try Rotating Backwards**—There is some merit to rotating the shifts in reverse order. In this case, the worker loses one shift for each of two shift changes and then picks up the two lost shifts at the third change. We show this reverse rotation in Fig. 5. You will note that operator A, at the end of the first cycle, leaves his job at 8.00 A.M. on Saturday and does not return to work until 4:00 P.M. Tuesday. Operators often prefer this reverse rotation because of the long weekend that occurs at regular intervals.

Having established a schedule for one operator (or operation) you can now set up a schedule for the entire crew. There are two ways to do this. The simplest, of course, is to consider the schedule to be for the entire crew; that is, operator A becomes "Shift A" and the entire complement of men, including the shift supervisor, rotate together.

The merits of this system are obvious: the men work together as a team, they always work under the same supervisor, they can share rides in their car pools, etc.

However, there is another procedure with merit.

A separate schedule is set up for each operator and the rotation of each man is offset to keep the rotation out of phase. The men work with different operators on each shift and there is a greater tendency for the operator to associate himself with the requirements of his job rather than the requirements of the crew. The constantly changing pattern of the crew will lead to greater uniformity of operations throughout all three shifts and the shift supervisor will become acquainted with the abilities of all the men.

This last is important when considering your personnel for either up- or downgrading since you will have the opinions of four supervisors instead of one.

▶**Scheduling the Six-Day Week**—For the six-day week, we have: 21 shifts/6 shifts per man = $3\frac{1}{2}$ men.

This $3\frac{1}{2}$ men is an unfortunately awkward figure. With the five-day week, we could handle the 1/5 man quite easily by working one man an extra shift. But in this case, one half of a six-shift man would be three shifts. Thus, each of your three men would have to work one extra shift which, of course, increases your six-day week to seven days.

One way to handle this situation is to work out a schedule for a two-man unit on each shift. This then gives 42 shifts/6 shifts per man = 7 men.

Now, with six days worked and one day off, we are on a natural seven-day period. But to avoid working with a very long cycle, we use a different procedure—we rotate the day off.

If each man is to get a day off each week, we must rotate the days off in a forward direction—Sunday, one week; Monday, the next. Fig. 6 shows this schedule. As you can see, this requires seven days worked consecutively, which is a disadvantage, but this is offset to some extent by the long weekend that comes every seven weeks. In effect, the day off comes one day later each week for seven weeks, then comes seven days early. This puts these two days off "back-to-back."

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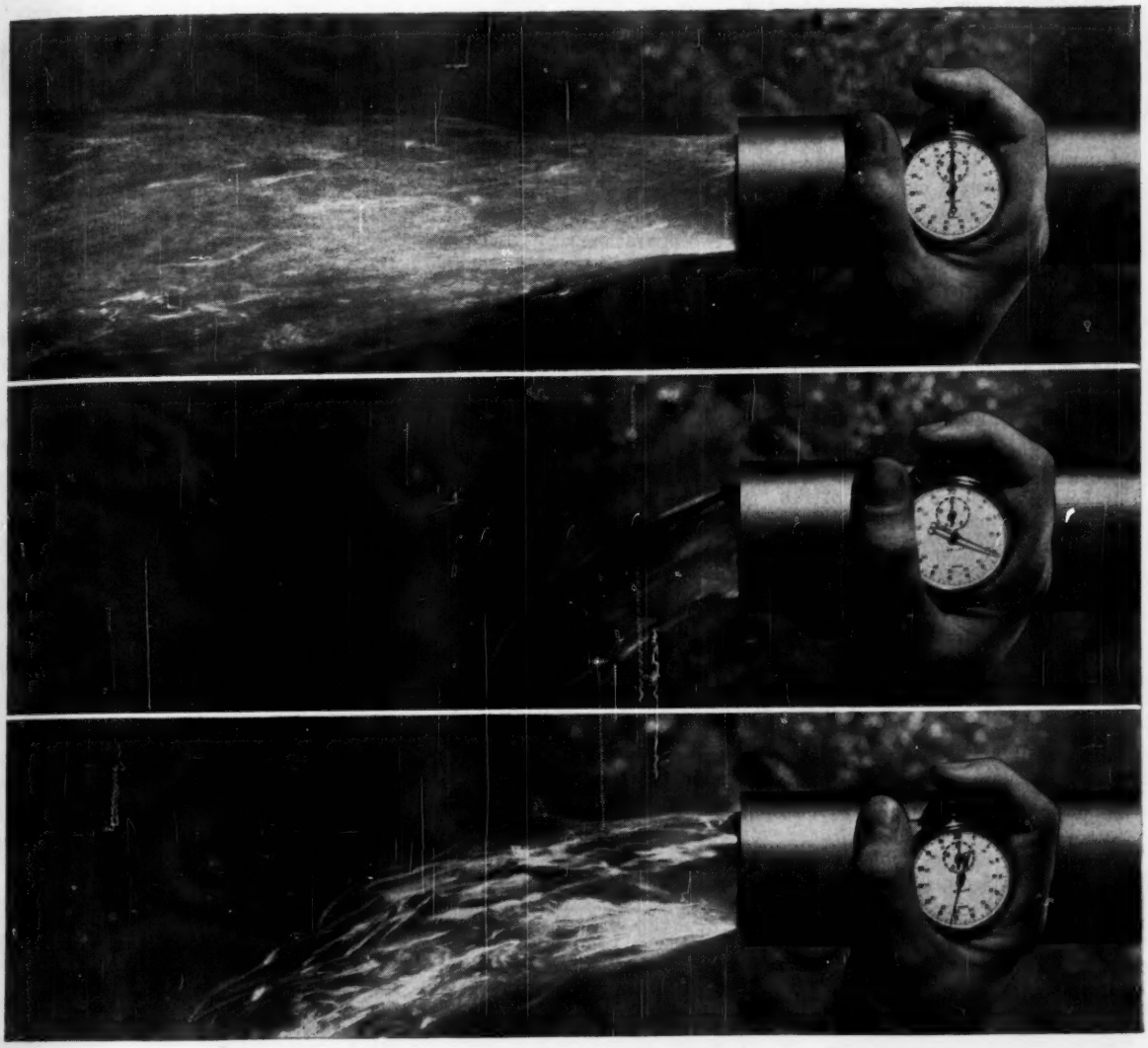

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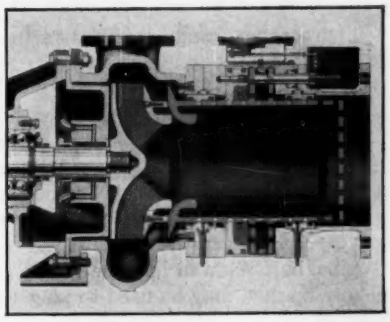

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The value of the long weekend can be further enhanced by reversing the rotation of the shifts as shown in Fig. 7. You will see here that operator G leaves the plant at 8:00 A.M. on Friday and does not report back until 4:00 P.M. Monday.

If your operations require a single operator with specific skills on each shift—for example, a "Reactor Operator" and an "Evaporator Operator"—the seven-man arrangement can be divided as shown in Fig. 8. Here only one man is needed with skill in both jobs and he works a "swing" shift between the two operations.

▶**Avoid 16-Hour Days**—If we rotate the days off in reverse direction, we get the advantages of the five-day working period. However, at the end of the days-off cycle, we have two working periods coming back-to-back, as shown in Fig. 9, and you periodically have an operator or shift scheduled to work 16 hours in a row. We can see this in the case of operator B on Saturday the 14th and Sunday the 15th, but we can fix it by reversing the shift rotation.

By decreasing the cycle of the "missed day off" to every sixth week, we get the schedule shown in Fig. 10. You will note that the changing of shifts during the long work period in this schedule always provides for four shifts between the two working periods, and that the long working period has been reduced from 12 days to 10 days.

Fig. 11 shows how we can split the schedule to provide dual coverage with a swing operator.

▶**Follow These Easy Guides**—We can summarize the subject of shift scheduling in seven simple rules:

1. Prepare a work sheet.
2. Determine your labor requirements.
3. Determine the cycle of days worked and days off.
4. Mark in the cycle of days off on your work sheet.
5. Schedule days and shifts worked through a complete cycle for one operator. You can start with any shift unless a special requirement exists. For example, in Fig. 10, you should start with operator F at the change of shifts in the long work period, marking the first and third shifts.
6. Start marking in the shifts for the second operator on a day when both the first and second operators are working to prevent conflicts.
7. Always work with a pattern. Any attempt to juggle the schedule of a single operator to balance out a schedule is almost certain to lead to difficulty at some other point in the schedule.

Meet the Author

RALPH H. WING *knows whereof he speaks, having had a great deal of experience as both originator and victim of misbegotten shift schedules. Prior to his present position as Assoc. Professor of Chemical Engineering at W. Va. Inst. of Technology, Montgomery, W. Va., Prof. Wing was an operating man with long service in the business of designing, building and running chemical plants.*

He received his B.S. and M.S. in chemical engineering from Ohio State U. and is a member of AIChE.

New Field Repair Method for Leaking Pipes Uses Epoxy Resins

Now you can repair holes in pipe, without an open flame and without entirely removing the pipe from service, in as little as 10 to 30 min. Anyone can do it on any diameter pipe operating at pressures up to 100 psi.

The pipe repair method uses an epoxy resin that is not affected by gasoline, fuel oil, crude oil or other hydrocarbons, and is resistant to most chemicals. Pressure extremes and increased corrosive action at higher temperatures limit practical operating temperatures of the resin, but the epoxy itself will withstand continuous operating temperatures in excess of 200 F.

To make a repair, you must first thoroughly clean the area around the hole in the pipe to assure a good bond between epoxy and pipe. Then you place a wad of vinyl tape over the hole. If there is pressure in the pipe, hold the wad in place with a steel band. Actually, any method may be used to plug the leak so long as it will hold until the resin is completely cured (2 hr.).

Next, wrap a layer of screen-like tape, called a "spacer," around the pipe for 6 in. on either side of the hole. This serves as a porous mold body for the resin. Cross-wound layers ⅛-in. thick are enough for a pipe carrying 20 psi. pressure.

Then you place a special injection fitting over the tape and wrap the entire area with half-lap windings of nonporous vinyl tape, which serves as the resin container. Finally, you wind a cloth tape over all to provide physical strength for holding the resin.

Mix the resin with the catalyst and place it in a pressure gun. Insert the nozzle of the gun into the injection fitting and pump resin into the patch until droplets appear at vent holes you previously punched in the outer layers of tape.

The resin hardens in about 30 min. and cures completely in less than 2 hr.

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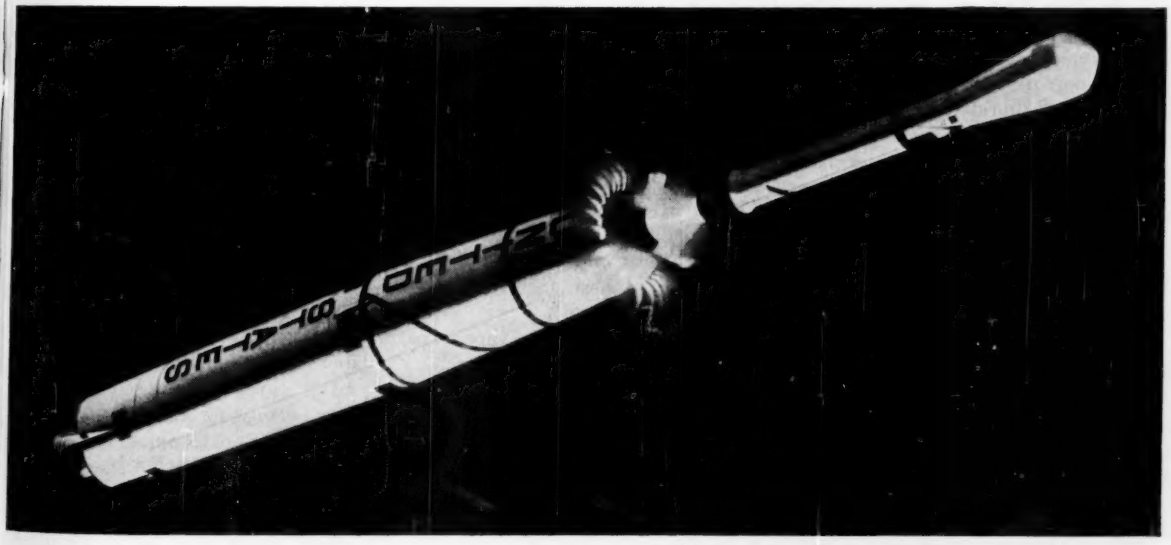

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

CORROSION-CONTROL DESIGN 7a

Part of a series appearing throughout 1960

Guides to Reducing Agitator Failures

For severe corrosive service, design factors such as agitator location, type of agitator, solids content of the slurry, must be considered to avoid premature failures.

NORMAN H. PARKER, *Tower Iron Works, Inc.*

One basic problem, common to many chemical plants, involves selecting proper materials of construction for process agitators.

From a corrosion standpoint, a very simple solution is to make the agitator out of the same material as the tank.* In many cases, this is perfectly adequate, but with severe or unusual corrosion situations it might not be the correct choice, and the proper material must be combined with adequate design to minimize corrosion.

To arrive at a basis for such design, let's first analyze and reduce the problem to some common denominators. Of course, it's obvious that corrosion can occur above or below the liquid level in a mixing tank.

▶ Vapor and Liquid — Agitator parts subject to vapor - space corrosion in a vertical tank include the upper shaft, in-tank couplings in the vapor space, shaft seal and, when there is a variable liquid level, the impeller or impellers through which the liquid level rises and falls.

Liquid-phase corrosion is confined to those mixer parts always below the liquid level: impellers, lower shaft, and guide or steady bearing, if any. The shaft seal would be included if the unit were side entering. The word impeller is used here in the broadest sense to apply to all types of mixing devices: turbines, propellers, anchors, paddles.

▶ Corroding Vapors—When we are dealing with the vapor space, we can be reasonably precise in defining three causes of corrosion:

- Liquid mist in the vapor space.
- Corrosive reaction-product vapors.
- Splashing.

A contributory factor to all three may be liquid-level variation inherent in operation of the system.

How can these factors result in agitator corrosion?

Liquid mist in the vapor space will result in major corrosion when individual droplets contain a concentration of a corrosive material that exceeds the limits which the construction material will withstand.

This effect will show up first on water-cooled shaft seals. Although the tank temperature may be high enough to prevent condensation, the cooled shaft-seal housing provides a condensation surface. Damage to the shaft and shaft seal results from either the corrosive effects of a high concentration or crystallization of a solid.

Product vapors are a definite source of vapor-space corrosion. Often, the vapor phase in equilibrium with a noncorrosive liquid can be the corrosive agent, or the presence of minute quantities of water vapor can react to form corrosive-product vapors.

Splashing, or variation in liquid level, will contribute towards high concentrations of corrosive materials. These effects, as with liquid mist, are almost impossible to predict or calculate, but wherever mixer parts are exposed to a condition permitting droplets of varying concentration to exist, a source of vapor-space corrosion has been set up.

Even the presence of air in the vapor space may be a corrosion-inducing factor, since oxygen is a corrosion accelerator under a wide variety of conditions.

An interesting example of this

* For a discussion of tank design, see *Chem. Eng.*, May 2, 1960, p. 150 and May 16, 1960, p. 170.

Previous articles in this series:

1. Plant Site, Layout Minimize Corrosion, Jan. 11, 1960, p. 144.
2. Proper Design Voids Equipment Corrosion, Feb. 22, 1960, p. 162.
3a. Often Overlooked Reactor Design Factors, May 2, 1960, p. 150.
3b. Keys to Corrosion-Wise Reactor Design, May 16, 1960, p. 170.
4a. Valve Design: Special for Corrosives, June 13, 1960, p. 238.
4b. Valves for Severe Corrosive Service, June 27, 1960, p. 146.
5a. How to Extend Storage-Tank Life, July 25, 1960, p. 148.
5b. Design Tips Reduce Tank Failures, Aug. 8, 1960, p. 154.
6. Better Design Stretches Exchanger Life, Oct. 17, 1960, p. 214.

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Choosing the right impeller...

...first step in minimizing mixer corrosion

Fig. 1 For solid-liquid suspensions:

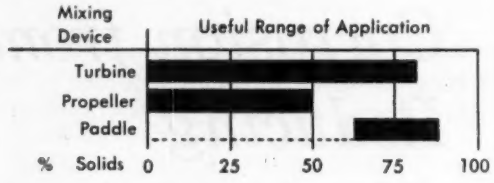
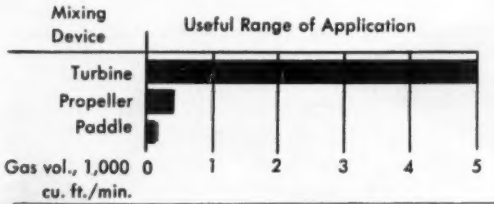


Fig. 2 For gas-liquid applications:



	Important Criteria	Space Relationships for Turbine Designs: Tank Dia. to Impeller Dia. Ratio	Space Relationships for Turbine Designs: Tank Ht. to Diameter Ratio	Impellers and Position
Fig. 1	Circulation Velocity	2.0:1 to 3.5:1	1:1 to 1:2	Depending on particle size: One impeller diameter off the tank bottom for fine particles; Impeller close to bottom for coarse particles
Fig. 2	Controlled shear Circulation High velocity	2.5:1 to 4.0:1	4:1 to 1:1	Multiple: lowest, one impeller diameter off bottom; Self-induction: place just below liquid level

occurred 4 yr. ago: In a series of carbon-steel horizontal autoclaves, where an ore was dissolved in the presence of air in a slightly basic solution, pitting and corrosion was found along the liquid-level line and for several inches above and below it. None of the materials in the solution or in the ore were capable of producing such severe corrosion. The immediate solution to the problem was to install an alloy liner extending above and below the liquid level, covering the zone of corrosion. However, subsequent analysis revealed that an unexpectedly high concentration of oxygen in the droplets at the liquid level and in the froth was the corrosive agent.

In dealing with liquid-phase corrosion, a great number and variety of possibilities suggest themselves. Each, separately or in combination, may be the cause of severe corrosive conditions. In order of importance, they are:

- Construction of the mixing device.
- Presence of gases or solids in the liquid.
- Galvanic action.
- Corrosive liquids.

Basically, the design and construction of a mixing device will determine if any galvanic corrosion is to take place and will also determine the extent to which presence of solids or gases or both will create corrosion problems.

▶ **Corroding Solids**—The presence of solids can be a source of major difficulty. To properly evaluate this problem, certain limits must be established. These include: type of solids, weight % in the liquid, particle size, and the type of mixing device.

Referring to Fig. 1† we see the ranges of % solids in which the three major types of mixing devices —the propeller, turbine, and the paddle—can be effectively applied in practice.

The propeller can be used up to 50% solids, the turbine up to about 75%, and the paddle effectively in a range from 60 to 80%.

In the article from which this drawing is reproduced, the authors discuss the relationship of particle size to impeller position. Impeller locations for solids suspension varies with particle size, the coarser solids requiring a lower impeller position in the tank than fine solids. Improper positioning produces a concentration gradient from the bottom to the top of the tank, with the coarsest solids in the impeller zone. This will cause abrasion failure of the impeller.

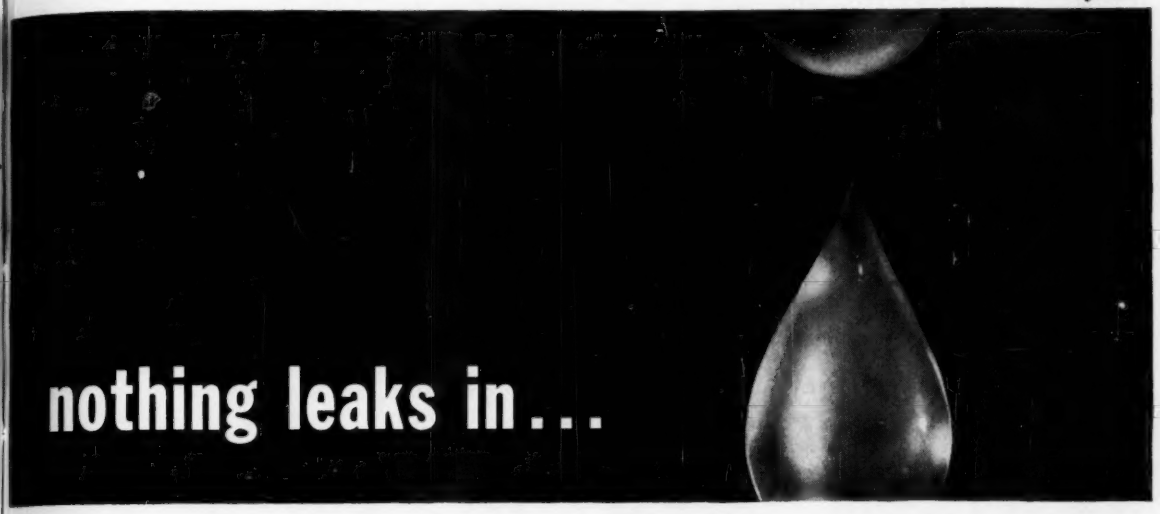
The special features that characterize each impeller design play a large part in the corrosion and abrasion problems to which they are subject in the liquid phase.

▶ **Three Mixer Types**—There are two basic types of flow developed by impellers. The propeller is an axial-flow device. Its blade shape provides maximum flow, parallel to the shaft, at a constant velocity at all points on the diameter. The turbine impeller is a radial-flow device that take advantage of centrifugal force. Velocity increases as the material flows toward the impeller tip.

The angled-blade turbine, with its straight blades set at an angle to the vertical centerline, was first

† Parker, N., et al, *Mining Eng.*, **8**, 288 (1956).

ALLIS-CHALMERS



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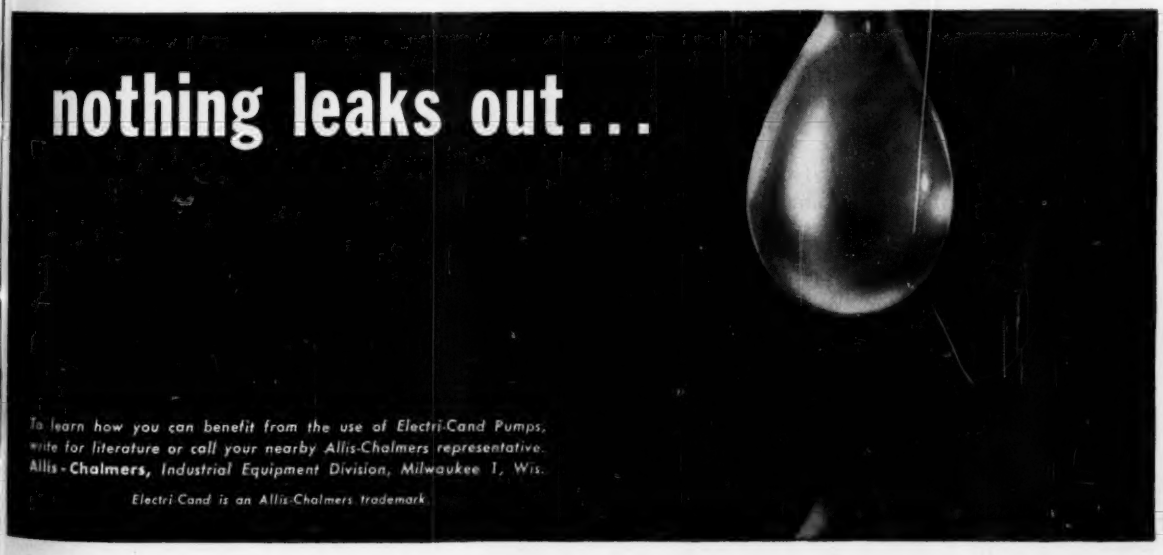

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developed to combine the radial-flow characteristics of the turbine with the axial flow of the propeller. However, it is a great deal less efficient than the propeller as an axial-flow device, and since only the projected height is the effective blade height for radial pumping, it is also less efficient than a turbine impeller whose blades are vertical.

The paddle, because of its low peripheral speed, does not usually have a major radial velocity. When used in unbaffled systems, it imparts almost the same peripheral velocity to the tank contents as its own.

The comparative ranges of peripheral velocities for the propeller, turbine and paddle are 4:2:1, based on 350 ft./min. for the paddle.

Although it is not customary to classify solids by hardness, this is a factor affecting the performance of corrosion-resistant materials in solids suspension. An abrasive slurry will reduce the wear-life of an impeller, and in combination with corrosive liquids, produce rapid failure. The rate of deterioration can be related to design of the impeller.

▶**Turbine Cuts Abrasion**—In the early days of the uranium boom, when it was important to put plants into operation quickly, many leach circuits started out with modified marine propellers as the mixing devices. A combination of the presence of coarse, abrasive materials in the ore, and the high peripheral speed of these propellers required to maintain suspension of the solids, produced severe reduction in wear-life, even in alkaline slurries. But, no difficulty was encountered in the precipitation steps where paddles were used.

Introduction of the turbine impeller, as the mixing device, into the leach circuit was a great step forward in the reduction of abrasion-corrosion failure. However, the paddle remained the mixing device most often selected for the precipitation operation.

In corrosion induced by, or as a result of, the presence of gases in the liquid, we encounter some similarity to vapor-space corrosion.

Visualize a system in which a gas reacts with a liquid. The gas is introduced below a mixing impeller so that it may be immediately dispersed by the liquid pumped by the impeller.

The primary function of the impeller is to achieve optimum gas-liquid contact and transfer. To do this, the impeller must produce, as a result of shear forces, a gas bubble that has neither too great nor too small a surface to promote mass transfer, no matter which film controls. In addition to this, the impeller must provide sufficient recirculation of liquid to minimize escape of a gas bubble.

Reference to Fig. 2 shows that the turbine impeller is best suited to this application.

▶**Localized Buildup**—But each of the various turbine impeller designs available today has the same basic limitation. For a given diameter, number of blades, blade width, and speed, there is a single volume flow obtainable. When circulating a gas fed to the impeller or entrained in the liquid, total volume pumped does not change, but the volume of liquid pumped is reduced as the volume of gas increases in the liquid. The volume pumped may be increased by increasing the rpm., but the power requirement increases with the cube of the speed while the circulation rate does not. The result: power requirements can very easily go beyond practical limits without a proportional increase in circulation.

Thus it is possible to overload impellers with feed gas, resulting in a localized high concentration of corrosive vapor, as well as poor reaction rate.

Since the turbine impeller is basically a caseless pump, it is also subject to cavitation caused by collapse of a vapor cavity at a metal surface.

By improper impeller location and high recirculation rate, it is also possible to maintain a higher concentration of a corrosive reaction product in the impeller zone. Under proper conditions, this product would be diluted by the balance of the ingredients in the tank.

A corollary action would be to cause the precipitation of an intermediate or other reaction product on the impeller and adjacent surfaces.

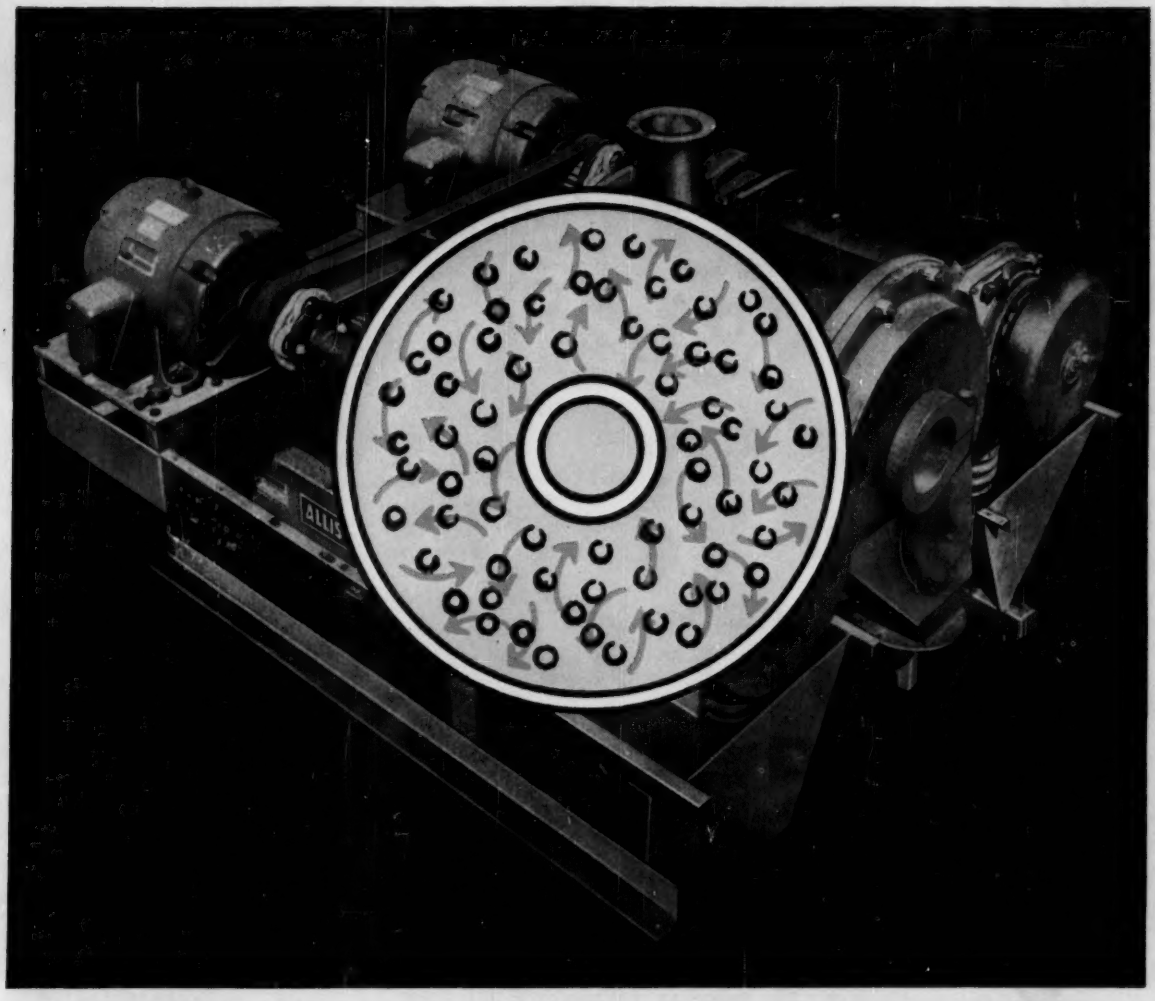
An interesting example of this latter problem occurred in this fashion: In a multiple-stage metal-leaching operation, air was used to form a soluble metal product. However, dissolved CO_2 and calcium ions, reacting with oxygen in the excess air, formed a surface coating of carbonates on the air distributor and the impeller. Buildup was at a predictable rate, based on the total flow of material in the system. Fortunately, the abrasive slurry in the final leach stage removed the coating in a predictable length of time. By rotating the mixers from the first to the third, through the second stage, then back into the first, service life of the impellers was lengthened and the cleaning problem was solved at the same time.

▶**Second Article Coming** — The second part of this discussion on agitator design will take up specific design factors such as bolted vs. welded construction, bearing location, blade shape, sealing devices.

Meet the Author

NORMAN H. PARKER, *with many years of experience on mixer design, is manager of the Industrial Div., Tower Iron Works, Providence, R. I. Previous to this, he was manager of engineering for the Turbo Mixer Div. of General American Transportation Corp. A chemical engineer from Brooklyn Poly, Mr. Parker is a licensed engineer (N. Y., R. I., Ill.) and a member of AIChE and NSPE. He is the author of three articles on buyer-seller relations that appeared in the Dec. 14, 1959, Dec. 28, 1959 and Jan. 25, 1960 issues of* CE.

ALLIS-CHALMERS



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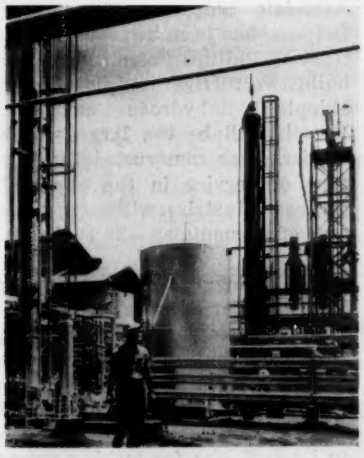
CPI NEWS BRIEFS . . .

(Continued from page 90)

over $9 million. Project will also include salt-cavern facilities for liquid storage.

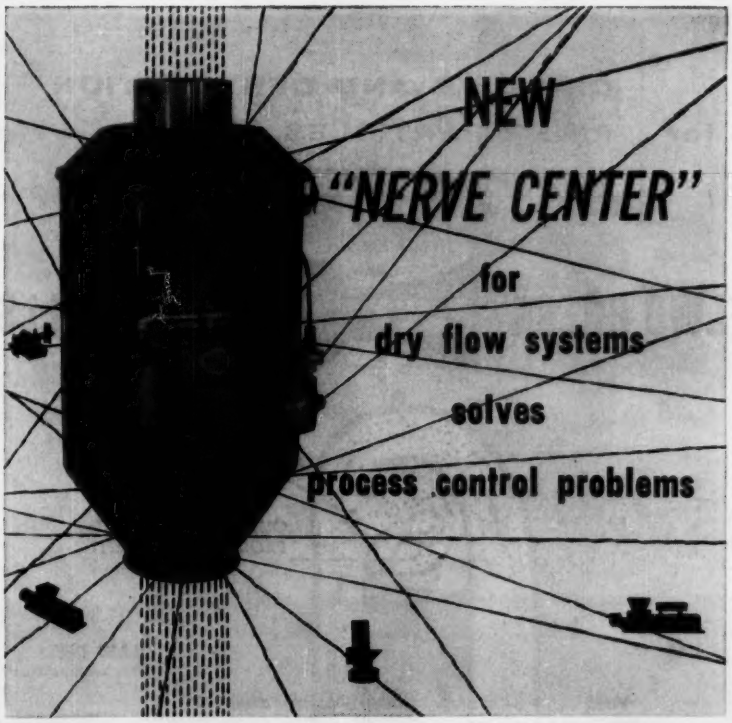


Jefferson Chemical Co. has completed first-phase modifications and new construction on the chemical plant at Conroe, Tex., that the firm purchased from Gulf Oil Corp. last year. Unit, part of which can be seen above, is producing polypropylene glycol, propylene oxide triols, morpholine and specialty surface-active agents. Other products will probably be added to the list in the future and the company also plans to use the facilities for development of new processes and intermediate-scale manufacture of new products.

Jamesbury Corp., manufacturer of ball valves, plans to start building an 80,000-sq.-ft. plant at Worcester, Mass., next spring.

Radio Corp. of America has opened an Electronic Data Processing Center in Chicago. Facility is available for use by firms in the Chicago area, is the fourth in a chain of such RCA systems that will eventually span the country. (First three: in New York, Washington, D. C., and Cherry Hill, N. J.) All four feature the RCA 501 processing unit.

Aerojet-General Corp., subsidiary of General Tire & Rubber Co., has dedicated an $850,000 chemical research center at the firm's plant in Azusa, Calif. Facility, containing



The new W&T Massometer® senses flow in closed systems. It measures dry, free-flowing materials and translates the results into a 3-15 psi signal. The unit can be used to indicate or record. It also controls proportional blending . . . helps solve problems in all kinds of control situations.

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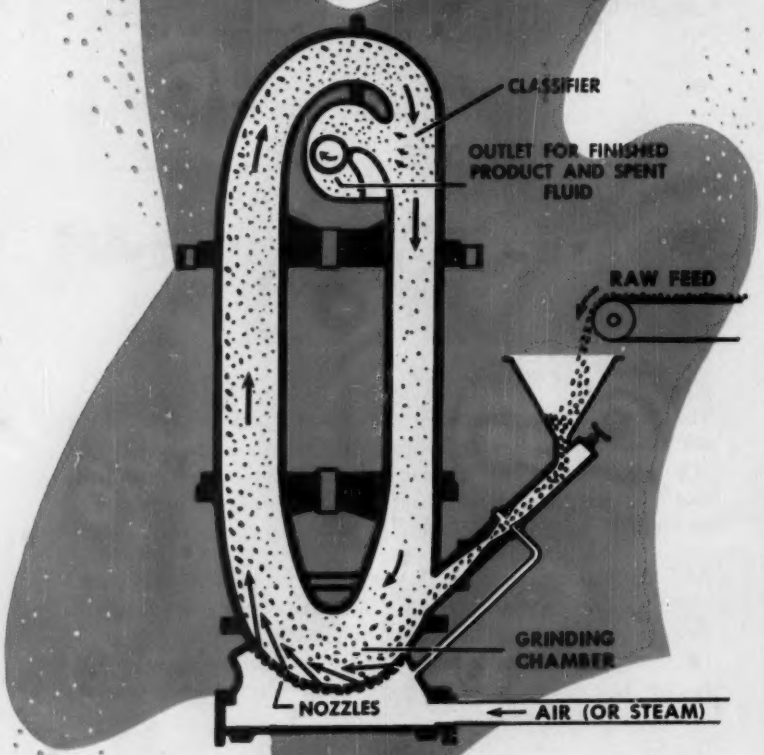

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26,000 sq. ft. of floor space, will be used for research on rocket propellants.

Avondale Shipyards, Inc., New Orleans, has been awarded a contract by Phillips Petroleum Co. to build two refrigerated barges for shipping anhydrous ammonia. Vessels will be the largest tank carriers ever constructed for this type of service in the chemical process industries, will carry 1,700 tons of ammonia at −28 F., 1 atm.

M. W. Kellogg Co.'s Power Piping Div. has started up a new manufacturing plant at Williamsport, Pa. Representing an investment of about $4 million, the installation features metallurgical and welding laboratories in addition to its facilities for making power piping for high-temperature, high-pressure service.

Monsanto Chemical Co. has completed an expansion of its Research Engine Laboratory at St. Louis, more than doubling its previous capacity for engine evaluation of chemical additives in fuels, motor oils, gear lubricants and automatic transmission fluids. New items include an additional battery of engine test cells, a photo room, expansions in an engine rebuilding shop, a garage, and storage facilities.

Robertshaw-Fulton Controls Co.'s thermostat division has opened a new $4-million manufacturing plant at Youngwood, Pa. It consolidates operations that were previously conducted at Youngwood, and Irwin and Scottdale, Pa.

Heyden Newport Chemical Corp. reports that construction is well under way for its forthcoming maleic anhydride plant at Fords, N. J. The facility will be able to produce 24 million lb./yr., and is scheduled to go on stream this coming January. An interesting feature of the plant will be the absence of a boiler house, which will not be required because the maleic anhydride process itself will generate 350-psig. steam.

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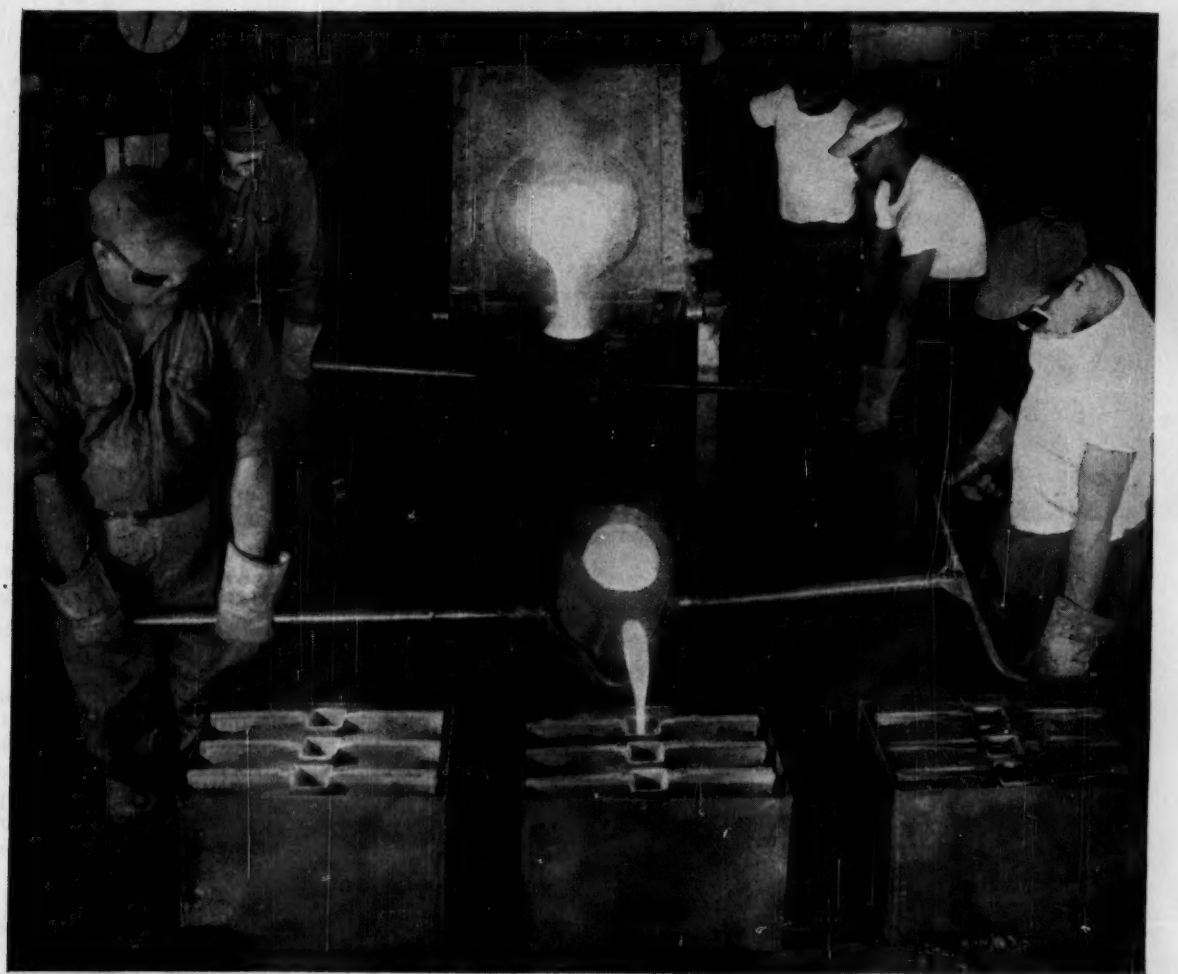

Part of Aloyco's foundry facilities include modern shell moulding techniques which permit unusually high dimensional accuracy. Radiographic inspection and dye penetrant testing are part of a comprehensive and rigid control program that assures castings of highest quality and uniformity.

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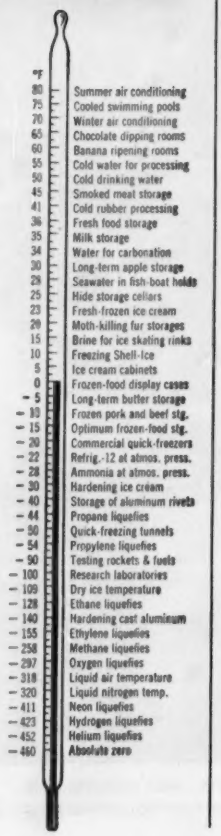
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80 Summer air conditioning
75 Cooled swimming pools
70 Winter air conditioning
65 Chocolate dipping rooms
60 Banana ripening rooms
55 Cold water for processing
50 Cold drinking water
45 Smoked meat storage
41 Cold rubber processing
36 Fresh food storage
35 Milk storage
34 Water for carbonation
30 Long-term apple storage
28 Seawater in fish-boat holds
25 Hide storage cellars
23 Fresh-frozen ice cream
20 Moth-killing fur storages
15 Brine for ice skating rinks
10 Freezing Shell-Ice
5 Ice cream cabinets
0 Frozen-food display cases
− 5 Long-term butter storage
− 10 Frozen pork and beef stg.
− 15 Optimum frozen-food stg.
− 20 Commercial quick-freezers
− 22 Refrig.-12 at atmos. press.
− 28 Ammonia at atmos. press.
− 30 Hardening ice cream
− 40 Storage of aluminum rivets
− 44 Propane liquefies
− 50 Quick-freezing tunnels
− 54 Propylene liquefies
− 90 Testing rockets & fuels
− 100 Research laboratories
− 109 Dry ice temperature
− 128 Ethane liquefies
− 140 Hardening cast aluminum
− 155 Ethylene liquefies
− 258 Methane liquefies
− 297 Oxygen liquefies
− 318 Liquid air temperature
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CPI NEWS BRIEFS . . .

Offices

Bird Machine Co., South Walpole, Mass., has opened an application engineering office at Walnut Creek, Calif., to serve current and prospective users of the firm's centrifugal and filtration equipment in the Western states.

Linde Co., Div. of Union Carbide Corp., has announced the opening of a new warehouse in South San Francisco, Calif., to supply rare gases and special rare-gas mixtures to industry in the Far West. Gases to be stocked include argon, helium, neon, krypton and xenon, as well as mixtures of these.

Companies

National Distillers & Chemical Corp. will acquire the operating assets of Minnesota Liquid Fertilizer Co. Latter firm, headquartered at Minneapolis, distributes anhydrous ammonia for direct application to soil, through 32 ammonia stations in Minnesota. ND makes ammonia, other fertilizer raw materials, at Tuscola, Ill., and other Midwest locations.

International Minerals & Chemical Corp. has contracted to buy E. Rauh & Sons Fertilizer Co., Indianapolis. Rauh operates three plants—at Indianapolis and Plymouth, Ind., and Sylvania, Ohio—and sells in the five-state area of Illinois, Indiana, Ohio, Michigan and Wisconsin. IMC will exchange 119,600 shares of its common stock for all of Rauh's stock.

Helmerich & Payne, Inc., Tulsa, Okla., a firm engaged mainly in producing oil and gas, has bought Natural Gas Odorizing Co. of Houston. Latter company is a supplier of mercaptans, which are used as odorants for natural and liquefied petroleum gases.

Maumee Chemical Co., Toledo, Ohio, has purchased a large chemical plant at St. Bernard, Ohio, from the Toms River Chemical Co., New York. Maumee will use the

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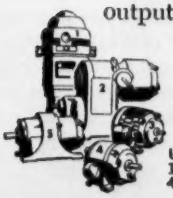

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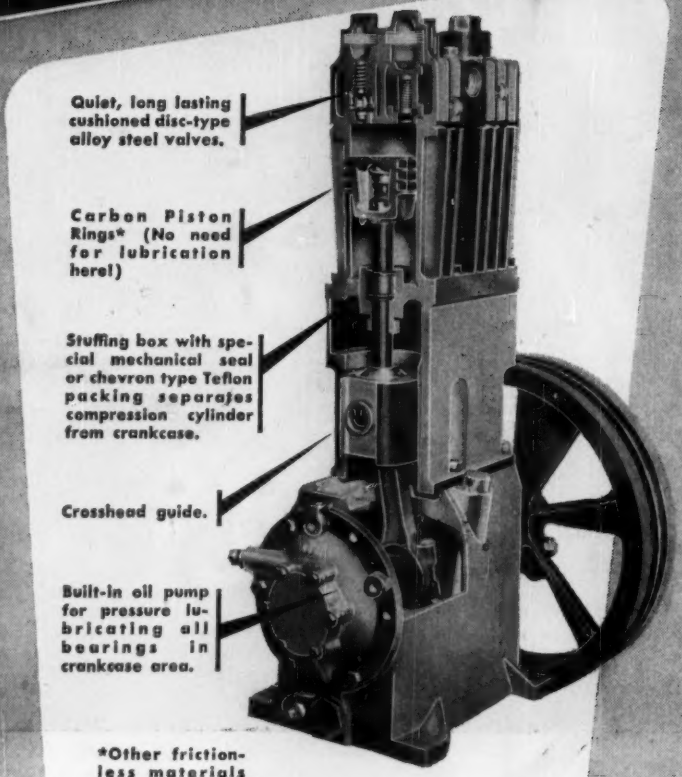
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facility to manufacture new organic chemicals for the pharmaceutical, food, flavors and chemical industries. Plant occupies a 21-acre site and it will have five times the capacity of Maumee's existing installation at Toledo.

Pfaudler Permutit Inc., Rochester, N. Y., has acquired AeroChem Research Laboratories Inc., of Princeton, N. J. AeroChem has done research on such subjects as the burning mechanism of solid propellants and the effects of combustion on heat transfer.

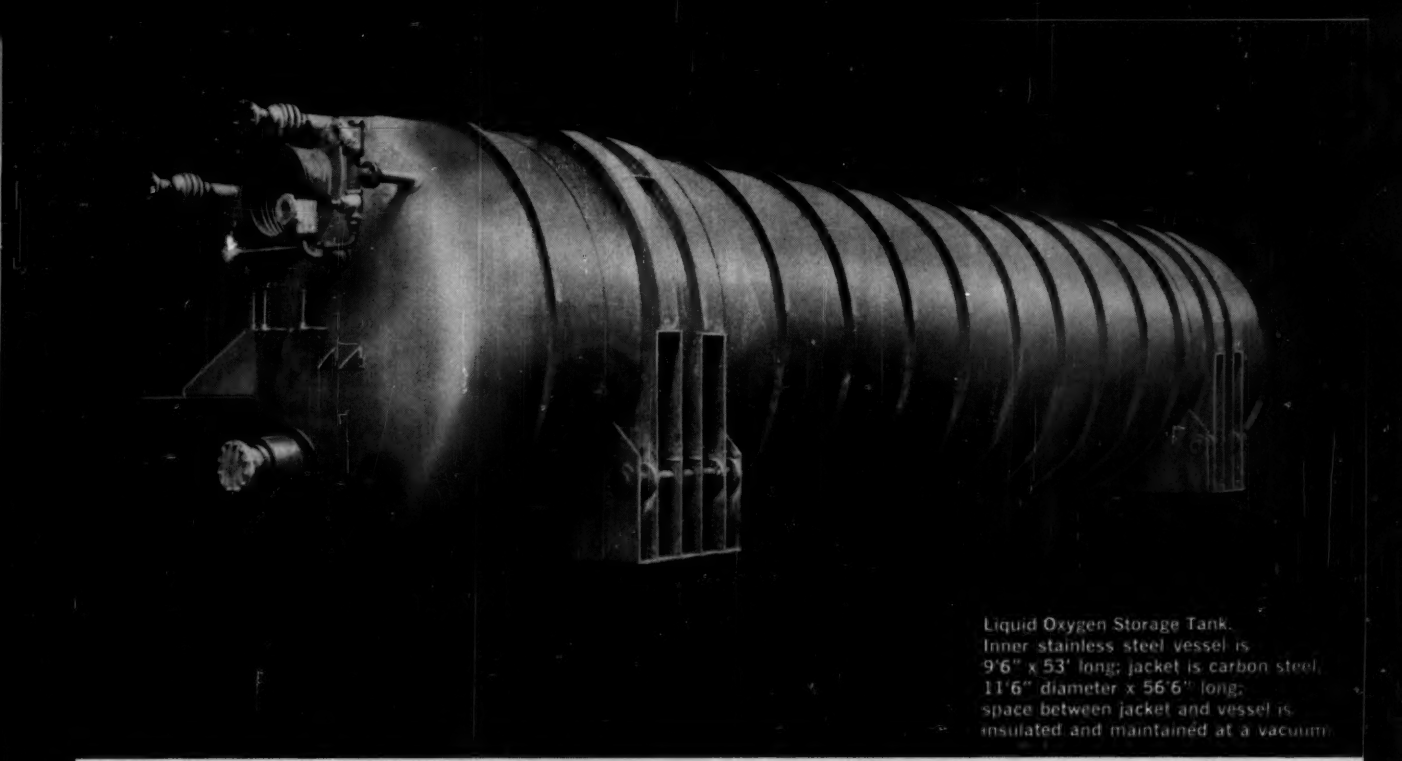
Armadillo Plastics, Inc., is the name of a new Houston firm that has been organized to manufacture tanks, piping, ductwork, plastic coatings, cements and adhesives for chemical and petrochemical facilities. Fabrication materials used by the new company include glass-reinforced polyester, epoxy and furan resins.

International

France: Societe Belge de L'Azote et des Produits Chimiques du Marly (S.B.A.), Liege, Belgium, will build a styrene plant for Ethyl-Synthese at Lillebonne, Seine Maritime, France. Facility will employ a process of Koppers Co. Inc., Pittsburgh, will have a capacity of 25,000-30,000 tons/yr.

Canada: West Coast Transmission Co. Ltd. will build a gas processing plant costing about $25 million at Coleman, Alta. Plant and associated pipeline will be engineered by Canadian Bechtel Ltd., and construction is to be completed by Nov. 1, 1961. Facility will treat up to 60 million cu. ft./day of gas from the Savannah Creek field, as well as additional gas from other sources.

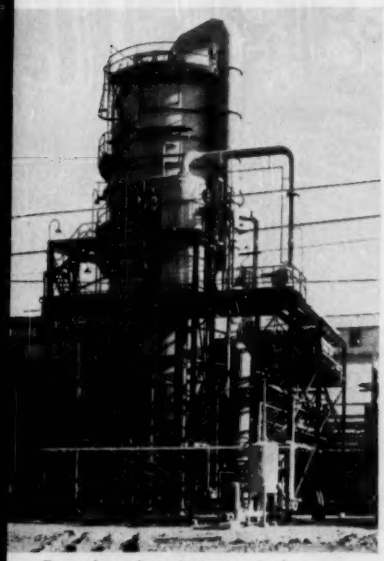
England: Dorman Long (Steel) Ltd., a major British steel firm, has announced an extensive development program that will cost over $100 million. Main object is not to expand capacity, but to increase efficiency over a wide range



Liquid Oxygen Storage Tank. Inner stainless steel vessel is 9'6" x 53' long; jacket is carbon steel, 11'6" diameter x 56'6" long; space between jacket and vessel is insulated and maintained at a vacuum.

STRUTHERS WELLS ENGINEERED EQUIPMENT

serves the nation's leading processing industries



Towering almost seven stories, this Krystal crystallizer produces premium grade ammonium sulfate.

Whether you require standard or specialized processing equipment, it pays to select the latest designs. Here are a few examples from today's modern, diversified product line designed and fabricated by Struthers Wells. The results, again and again, have been improved product, increased production and lower overall costs. Your company may also benefit by taking advantage of Struthers Wells' more than 100 years of experience in the engineering and manufacturing of process equipment.

For additional information and address of your local Struthers Wells representative, see Chemical Engineering Catalog, pages 1523 to 1542.

Struthers Wells

STRUTHERS WELLS CORPORATION

WARREN, PA. **Plants at Warren and Titusville, Pa.**

PROCESSING EQUIPMENT DIVISION

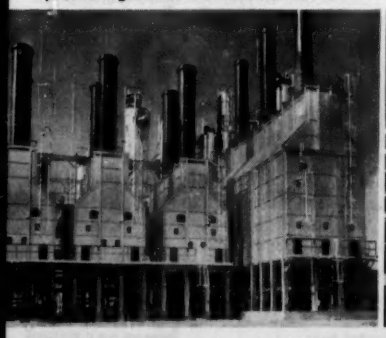
Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels

BOILER DIVISION

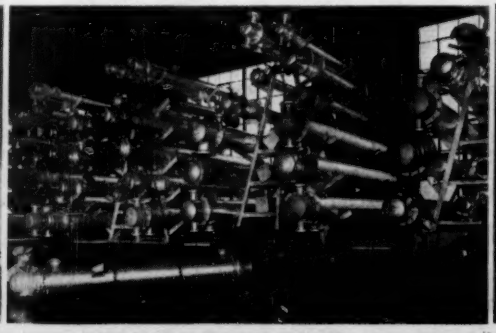
BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

FORGE DIVISION

Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening and Back-up Rolls

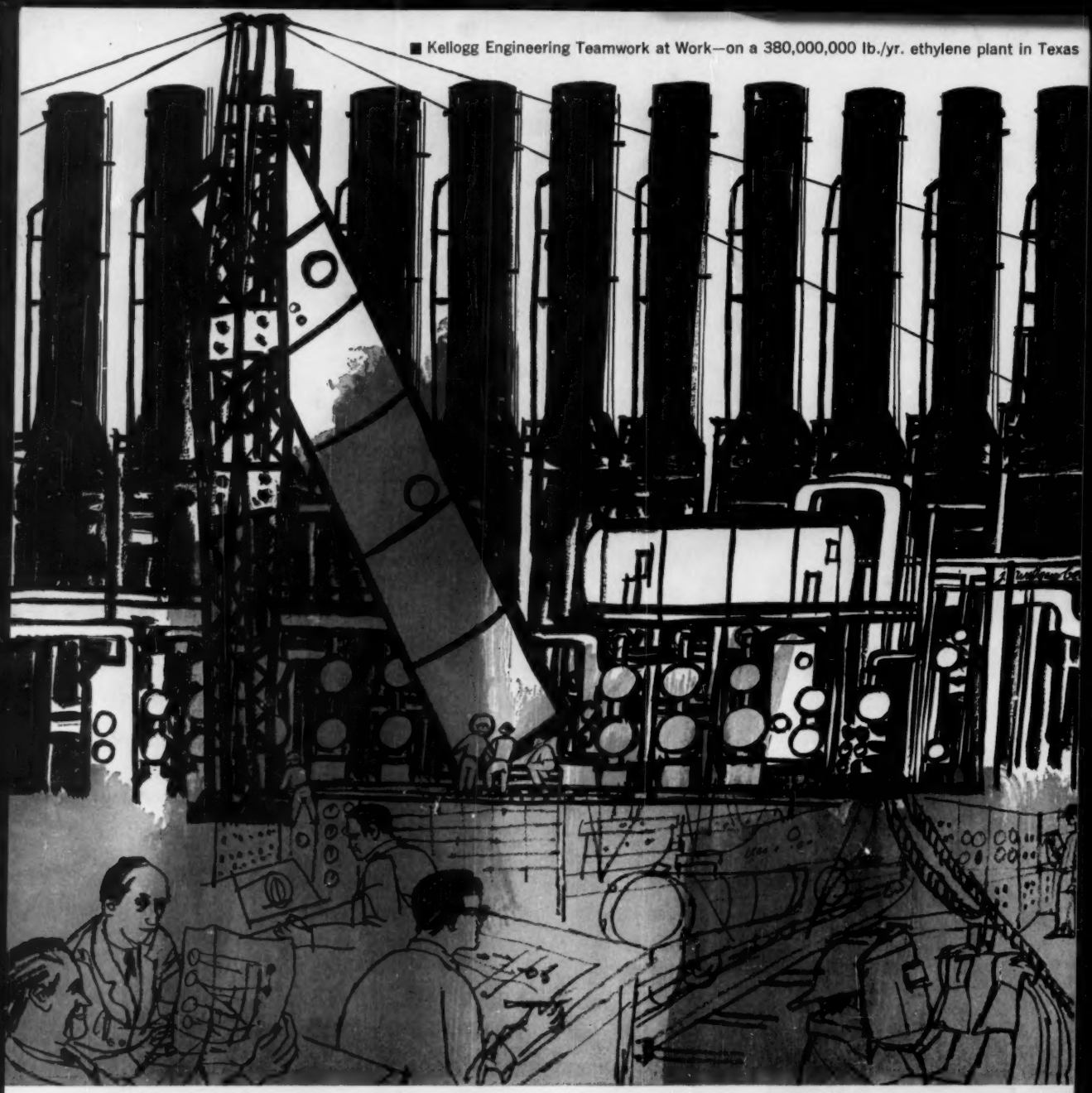


Four heaters, temperatures to 1450°F., serve Texas petrochemical plant.



Standardized heat exchangers available in sizes to 1200 square feet.

"Multi-Action" mixer with specially designed radial propeller.



■ Kellogg Engineering Teamwork at Work—on a 380,000,000 lb./yr. ethylene plant in Texas

CHEMICAL PLANTS FROM SCRATCH

For many of the world's leading chemical and petrochemical firms, the Kellogg method of executing a capital investment in new plants and plant expansions has proved the soundest way to minimize expenditure.

This economic route to new chemical plants consists of coordinating and controlling all phases of engineering, procurement, and construction under an internationally integrated management. It is founded on close teamwork among all Kellogg operations at home and abroad . . . and with client engineering staffs.

Kellogg's method has improved process and plant engineering . . . saved money in procuring materials and equipment . . . increased labor productivity . . . expedited erection . . . achieved the earliest possible on-stream dates . . . and stayed within predetermined costs. The result is the plant which achieves the optimum balance of investment and operating costs.

Working with clients on this basis, Kellogg has been responsible for a variety of chemical plants throughout the world. In the United States, current projects include: a 380,000,000 lb./yr. ethylene plant in Texas; an 18,000,000 lb./yr. epichlorohydrin plant in New Jersey; a 300 ton/day ammonia plant in Missouri; a 200 ton/day urea plant in Delaware.

If you are planning to build new processing facilities in the U.S. or overseas, Kellogg would be glad to show you how its engineering teamwork could work to your company's advantage. Please address inquiries to The M. W. Kellogg Company, 711 Third Avenue, New York 17, N.Y.

THE M. W. KELLOGG COMPANY / A Subsidiary of Pullman Incorporated

Offices of other Kellogg companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

M KELLOGG W

of operations. Items in the program include a new primary mill to produce 22,500 tons/week of slabs and blooms, a new, high-capacity universal plate mill and a new, high-capacity wire rod mill.

Pakistan is building a $50-million fertilizer plant, to be located on the Indus River near Sukkur. Product slate will include ammonium sulfate plus other fertilizers and the facility will have a capacity of 250,000 tons/yr.

India: Financing and construction plans are complete for a $12-million pulp and paper mill that Seshasayee Paper & Boards Ltd. will build in the State of Madras. Plant will produce 60 long tons/day of printing and writing papers from bamboo and sugar cane bagasse pulps. Construction is due to be completed by the fall of 1962.

Wales: British Hydrocarbon Chemicals Ltd., jointly owned by British Petroleum, Ltd., and The Distillers Co., Ltd., is developing plans for a petrochemicals plant that will be built near Llandarcy, where BP operates a refinery. The installation will operate similarly to British Hydrocarbon's plant at Grangemouth, Scotland, which cracks and further processes feedstocks received from a nearby refinery to make various chemicals. Initial investment for the new plant may amount to $28 million.

Norway: Titania A/S, a subsidiary of National Lead Co., New York, has opened its new Tellnes ilmenite mine and mill at Hauge i Dalane. Facility will make 300,000 tons/yr. of ilmenite concentrate, which will go to European manufacturers of titanium dioxide pigments. Cost of the new plant: $10 million.

Guatemala's first petroleum refinery, featuring a 4,000-bbl./day crude topping unit, a 2,600-bbl./day desulfurizer and a 1,200-bbl./day catalytic reformer, is scheduled to go on stream early next year. It is being built by The Lummus Co., for Breaux Bridge Oil Re-

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We FLO-CHILL Wyandotte Anhydrous Caustic Soda to make it easier for you to use. Try it . . . it's wonderful! It flows readily, even in hot, humid weather—which means you can use Wyandotte FLO-CHILLED Anhydrous Caustic Soda to advantage every month of the year. Order a supply soon from your Wyandotte representative or distributor.

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Add a Quality String to Your Bow...

WALLINGFORD

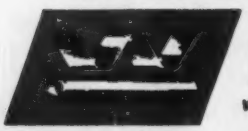
Stainless Strip and Tubing

If you are aiming at new design or performance targets for your stainless steel products — or parts — Wallingford can add an important quality string to your bow.

Every pound or inch of Wallingford Stainless Steel Strip and Tubing is of consistent, unmatched quality, because *Wallingford produces tonnage on a laboratory basis.* Exacting standards — unsurpassed in the industry — are maintained by utilizing the most advanced production control methods and facilities yet developed. Tensile tests, X-ray diffraction studies, automation gaging, laboratory samplings, and many other tests and techniques assure *super-quality.*

Are you presently getting this "quality insurance" when you purchase stainless steel? If not, contact The Wallingford Steel Co., Wallingford, Conn., for further data and a copy of our latest data book.

THE WALLINGFORD STEEL CO.



Progress in Metals for over 37 Years

WALLINGFORD, CONN., U.S.A.

COLD ROLLED STRIP: *Super Metals, Stainless, Alloy*

WELDED TUBES AND PIPE: *Super Metals, Stainless, Alloy*

fining Co., Inc., Houston. Plant site is in the jungle, near Puerto Barrios, and most of its facilities have been prefabricated in Texas and shipped by boat. The refinery will make premium and regular gasoline, kerosene, fuel oils, etc.

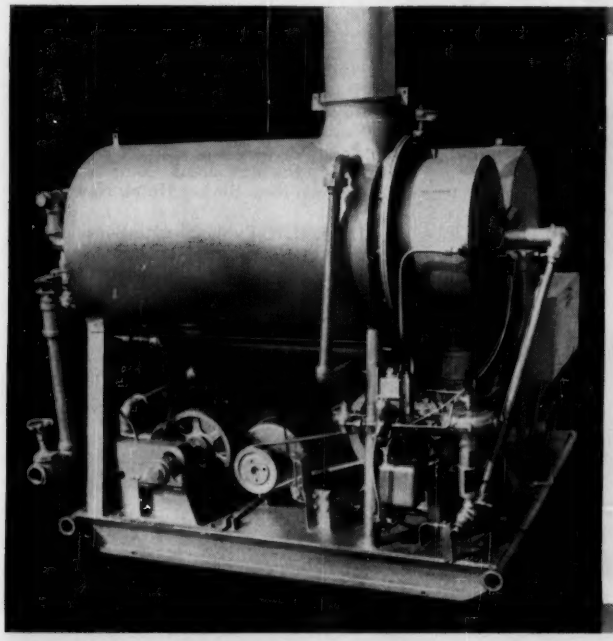
Greece: An undisclosed, large Greek company that makes fertilizers has commissioned Fertilizers & Chemicals Ltd., Haifa, Israel, to build storage facilities for anhydrous ammonia. Contracted price: $1 million. At the same time, an agreement was reached in which Fertilizers & Chemicals will supply the Greek company with aqua ammonia during construction and with the anhydrous form after the facilities are completed.

West Germany: BP Benzin und Petroleum AG, Hamburg, German associate of the British Petroleum Group, has officially opened its new BP Ruhr Refinery at Dinslaken. Facilities erected to date include two 50,000-bbl./day crude distillation units, a catalytic reformer, a sulfur recovery plant, and hydrofiner and copper chloride treatment units. Currently under construction are a catalytic cracking unit plus an associated vacuum still, and a bitumen plant. One feature of the refinery is a line-blending system under which finished products are blended as required from stored basic components.

Holland: Unilever-Emery N.V., Gouda, has gone on stream with a new oleochemicals polymerization plant in that city. Facility will initially manufacture two polyfunctional carboxylic acids known as dimer acids or di-linoleic acids. Polymerization process was developed by Emery Industries, Cincinnati, one of the parent companies of Unilever Emery.

Italy: A dehydrogenation unit with a nominal design capacity of 20,000 tons/yr. butadiene has gone on stream at Ravenna for ANIC of Italy. Unit uses the dehydrogenation process developed by Houdry Process Corp., Philadelphia.

Vapor Heating Corporation announces their



VAPOR MODULATIC ®

HI·R·TEMP

LIQUID PHASE HEATER

- Higher Temperatures
- Lower Pressures
- Lowest Installation and Operating Costs
- Least Maintenance
- No Water Treatment

The Vapor Modulatic HI-R-TEMP Liquid Phase Heater is a forced circulation, coiled tube, direct-fired heater of two-pass design. It provides dependable, automatic, accurately controlled heat transfer up to 600°F. at low pressure. Burns natural gas, propane, butane, No. 2 Diesel oil, or kerosene. Ideal for use in oil refineries; in concrete, chemical, plastics, food, plating industries; for oil or sulphur tankers...or wherever high temperatures are needed *without* high pressures.

check these advantages:

- **FULLY AUTOMATIC OPERATION.** Modulating controls automatically maintain predetermined temperature of heat transfer oil.
- **NO WATER TREATMENT NEEDED.** Eliminates cost of treatment system. No scale deposits, corrosion, freezing problems.
- **LOW PRESSURE VESSELS AND FLOW CIRCUITS.** No heavy piping, fittings or valves required.
- **LOW OPERATING COST.** Forced draft combustion, efficient coil design gives highly efficient operation.
- **LOW INSTALLATION COST.** Completely unitized and skid mounted with all piping in place, factory tested before shipping. Compact, lightweight, installs anywhere.
- **POSITIVE OIL FLOW.** Rotary gear pump assures uniform circulation...prevents hot-spots, coking, sludging, oil breakdown.
- **OPTIMUM SAFETY.** Built to ASME codes. Flame failure, low oil level, high temperature safety shut-off controls are standard. CO_2 quenching ring optional.

BRIEF SPECIFICATIONS

	Model No. 5410	Model No. 5425	Model No. 5435
Thermal Capacity BTU's per hr. input	1,250,000	3,120,000	4,375,000
Fuel, Gals/hr. No. 2 Fuel Oil	9	23	32
Fuel, Cu. Ft./hr. Natural Gas	1,250	3,120	4,375
Heating Surface Square Feet	109.7	130	170.4
Stack Diameter	10"	10"	10"
Length, overall	60"	83"	96"
Width, overall	36"	36¾"	53"
Height, overall	56½"	65"	63"
Shipping Weight, lbs.	2,000	2,700	3,700

Please send me free HI-R-TEMP bulletin no. 4023

VAPOR

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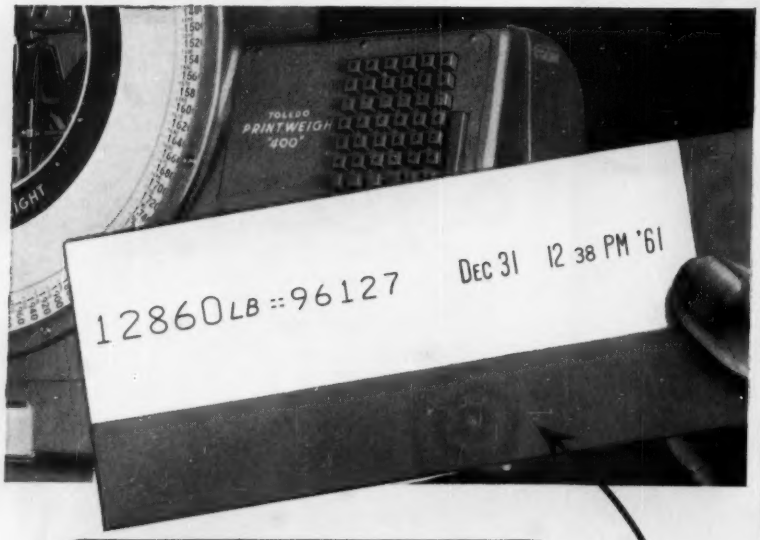
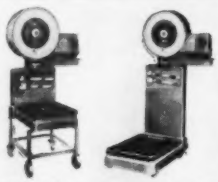
TOLEDO SCALES that PRINT Complete Weight Records for You . . .



. . . *THE ANSWER* to prevent "guesswork" and errors in cost control!



Toledo Printweigh Scales are available in a full range of models, including Built-in Hopper, Tank, Overhead Track and Motor Truck Scales, in addition to the models illustrated above.

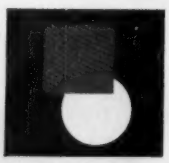
Human errors in reading, remembering and recording weights are eliminated with Toledo Printweigh "400" Scales. They're the surest way to satisfy your requirements for weight records that are complete and indisputable.

Weights are printed in full figures, even when unit weights are used. Choice of printing on 8½" x 11" forms, or on tickets; also on strips. Weight data may be transmitted electrically for recording on remote adding or other office machines. "Memory" feature available for printing weight data, even after load is removed.

Toledo Printweigh "400" Scales give new flexibility and efficiency in weighing . . . to cut costs, guard quality, prevent profit-stealing weighing errors. Ask your Toledo representative for the full story on Printweigh Scales, or WRITE TODAY FOR BULLETIN 2017. TOLEDO SCALE, Division of Toledo Scale Corporation, Toledo 12, Ohio
(Toledo Scale Co. of Canada, Ltd., Windsor, Ont.)

"MISFIT" SCALES MULTIPLY COSTS

Scales can become "misfits" as a result of changes in plant layout, materials handling, inventory controls, value or quantity of materials weighed. If this has happened in your plant, the results can be costly. For example: weighing errors, production bottlenecks, materials handling inefficiencies. Be sure your scales are adequate for the job. Ask your Toledo representative about a scale adequacy check in your plant, or send for the Toledo Weight Fact Kit.



SERVICE

TOLEDO® *Headquarters for Weighing Systems*

Convention Calendar

December

11-14. American Nuclear Society, 8th Hot Laboratory and Equipment Conference, Mark Hopkins Hotel, San Francisco, Calif.

11-14. Eastern Joint Computer Conference, New Yorker Hotel, New York.

12-14. U. S. Public Health Service, National Conference, "Problems and Progress in Water Pollution Control," Sheraton-Park Hotel, Washington, D. C.

12-15. Industrial Building Exposition and Congress, New York Coliseum, New York, N. Y.

14-16. Atomic Industrial Forum, Annual Conference, Fairmont Hotel, San Francisco, Calif.

26-31. American Assn. for the Advancement of Science, Annual Meeting, New York, N. Y.

January

16-18. American Astronautical Society, 7th Annual Meeting and Convention, Sheraton-Dallas Hotel, Dallas.

17-19. Instrument Society of America, Winter Instrument-Automation Conference and Exhibit, Sheraton-Jefferson Hotel and Kiel Auditorium, St. Louis, Mo.

23-26. 12th Annual Plant Maintenance & Engineering Show, International Amphitheatre, Chicago, Ill.

24-27. Society of Plastics Engineers, Annual Technical Conference, Shoreham and Park-Sheraton Hotels, Washington, D. C.

24-27. Canadian Pulp and Paper Assn., 1961 Annual Meeting of the Technical Section, Queen Elizabeth Hotel, Montreal, Que.

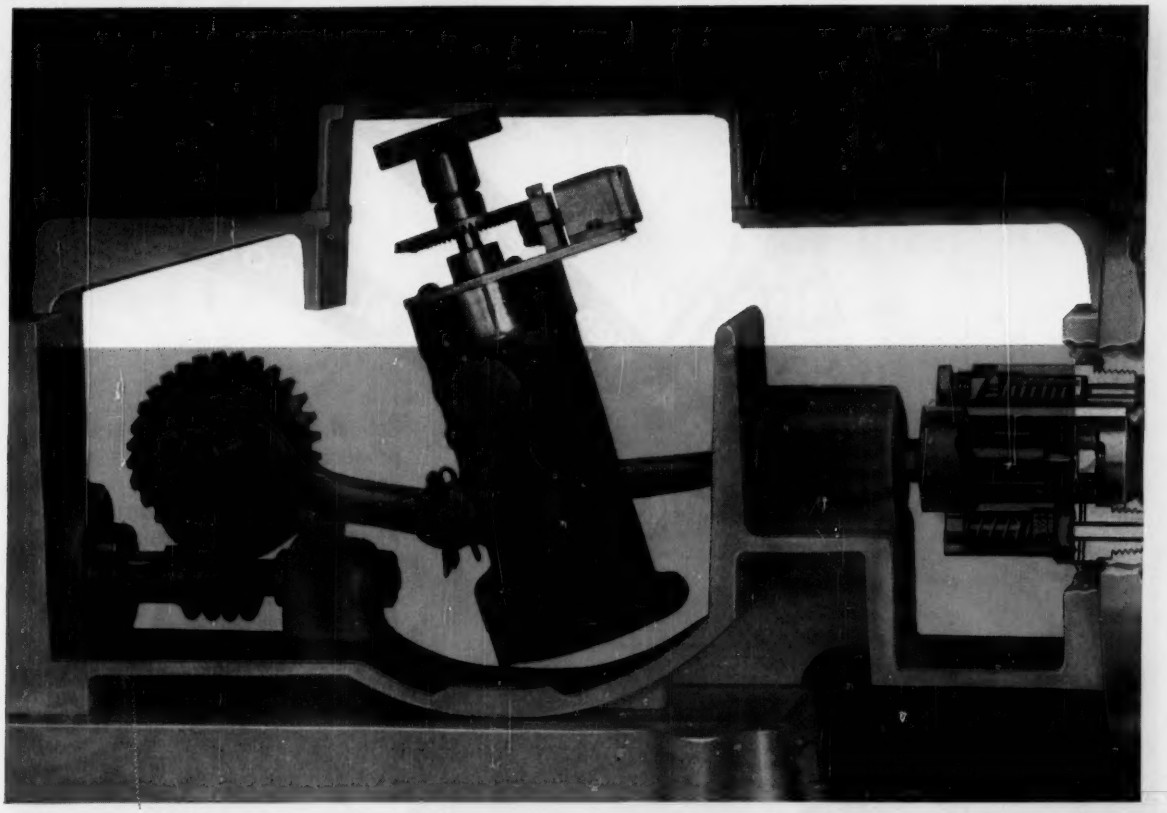
30-9. University of Illinois, Quality Control by Statistical Methods, Urbana, Ill.

February

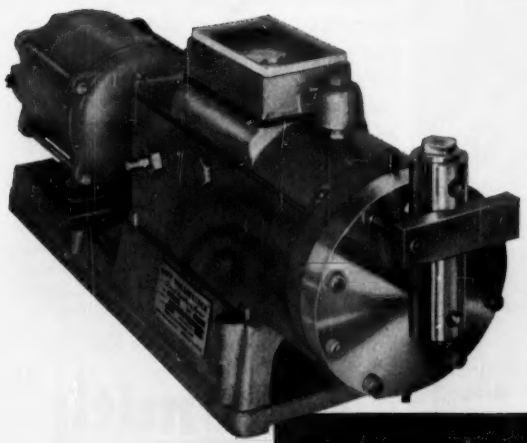
5-10. National Petroleum Assn., Symposium on Research on Gasoline, Benjamin Franklin Hotel, Philadelphia, Pa.

7-9. The Society of the Plastics Industry, Inc., 16th Reinforced Plastics Division Conference, Edgewater Beach Hotel, Chicago, Ill.

13-17. American Management Assn., Inc., Packaging Management Course, Hotel Astor, New York, N. Y.



This is why you never heard of a PULSAFEEDER wearing out!



Every moving part of every Lapp Pulsafeeder Metering Pump is completely submerged in oil. This total lubrication reduces friction to practically the theoretical minimum. And there's no possibility of corrosion from exposure to atmosphere.

For year after year of *extra* service life, Lapp Pulsafeeders continue to give you the exclusive advantages for which you bought them. Advantages like complete freedom from leakage and contamination; precision metering, at flow rates from a few drops to 15.7 gallons per minute; pressures up to 7000 psig; choice of heads for safe handling of acids, abrasive slurries, radioactive fluids; manual or instrument controls. We've got a new catalog to help you fit the right model to your process.

Lapp

***WRITE** for Catalog 59. Lapp Insulator Co., Inc., Process Equipment Division, 1112 Poplar Street, LeRoy, N.Y.*

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Behind every Glascote glass-lined product is an experienced sales engineer who can give you on-the-spot product and process assistance. And behind him, there are 40 years of Glascote experience in manufacturing glass-lined vessels and tanks for the petroleum and chemical industries.

Through continuous research and development engineering, Glascote stays ahead of the demand for new and improved processes requiring a wider range of corrosion, temperature and thermal shock-resisting properties for glass linings. For example, new Glascote 778 is the most corrosion-resistant glass ever applied to chemical and petroleum processing equipment — this without sacrificing any other protective property.

Glascote and its parent organization, A. O. Smith Corporation, have developed more than 3000 glass formulas — the best of these giving you superiority in glass-lined reactors, columns, storage tanks, rotary dryer-blenders, pipe and fittings. For additional information, ask your Glascote representative for specific product data. Or write direct: Glascote Products, Inc., Cleveland 17. Ohio.

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REACTORS · SPHERICAL REACTORS · COLUMNS · STORAGE TANKS · HEAT EXCHANGER TUBES · ROTARY DRYER-BLENDERS · PIPE AND FITTINGS

CALENDAR . . .

13-16. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 15th International Heating & Air-Conditioning Exposition, Chicago Amphitheatre,, Chicago, Ill.

26-1. American Institute of Chemical Engineers, Petroleum and Petrochemical Exposition, National Meeting, Municipal Auditorium, New Orleans, La.

March

5-9. The American Society of Mechanical Engineers, Gas Turbine Power Conference & Exhibit, Shoreham Hotel, Washington, D. C.

8-10. Instrument Society of America, 11th Annual Conference on Instrumentation for the Iron & Steel Industry, Roosevelt Hotel, Pittsburgh, Pa.

13-17. National Assn. of Corrosion Engineers, Annual Conference & Corrosion Show, Statler Hotel, Buffalo, N. Y.

20-24. American Society for Metals, 1961 Western Metal Show, Los Angeles Pan-Pacific Auditorium, Los Angeles, Calif.

21-23. Illinois Institute of Technology and American Society of Mechanical Engineers, American Power Conference, Sherman Hotel, Chicago, Ill.

27-31. Instrument Society of America, 3rd Symposium on Temperature, Its Measurement and Control in Science and Industry, Veteran's Memorial Hall and Deshler-Hilton Hotel, Columbus, Ohio.

April

6-7. American Society of Mechanical Engineers, Management Engineering Conference, Statler-Hilton Hotel, N. Y.

10-11. American Society of Mechanical Engineers, Maintenance & Plant Engineering Conference, Bancroft Hotel, Worcester, Mass.

10-12. American Welding Society, 42nd Annual Convention and Welding Exposition, Technical Meetings at Sheraton-Atlantic and Commodore Hotels, Show in New York Coliseum, New York, N. Y.

11-13. Air Force Research & Development Command, Conference on Ultrapurification of Semiconductor Materials, New England Mutual Hall, Boston, Mass.

12-14. American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., International Symposium on Agglomeration, Sheraton Hotel, Philadelphia, Pa.

chemical processors!

no capital investment for an over-the-fence oxygen plant built with

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CERTAINTY that your final cost of oxygen will not be upped from the original estimate. CERTAINTY that your cost over the contract period will be as low as possible, in keeping with requirements for purity and trouble-free operation . . . the result of LINDE's advanced engineering features.

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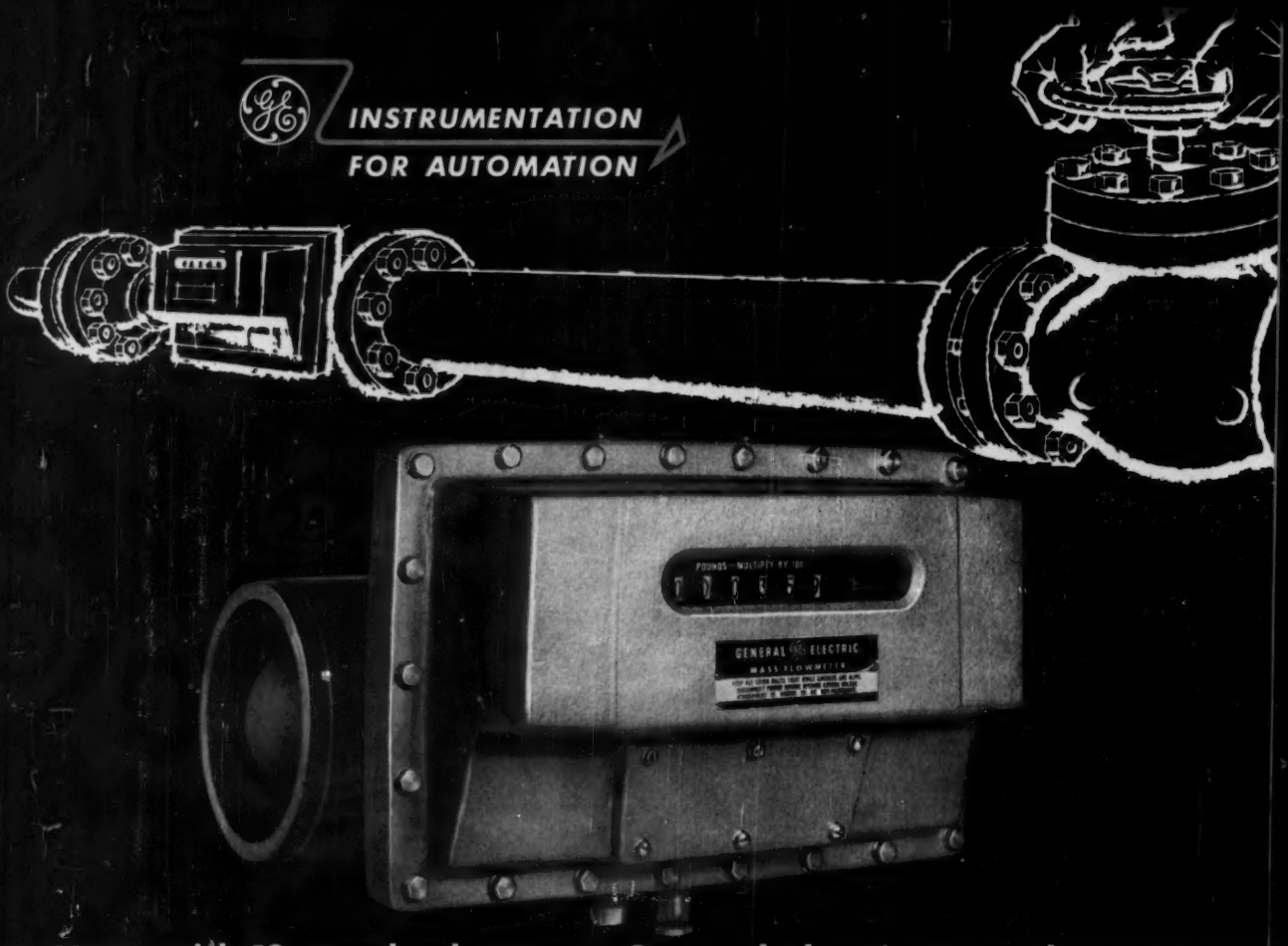
INSTRUMENTATION FOR AUTOMATION



Now, with 12 standard ranges, General Electric Mass Flowmeter

PERFORMANCE PROVED

. . . ON THE LINE! Today, many companies in the petroleum, chemical, petrochemical and natural gas industries are accurately measuring valuable process fluids directly in pounds with the General Electric True-Mass Flowmeter.

For example, these 12 applications have been performance-proved in actual service metering:

- **air • natural gas • alcohol • vinyl chloride**
- **freon • penicillin • liquid carbon dioxide**
- **ethylene • liquid petroleum gas • naphtha**
- **jet fuel • methane hydrogen mixtures**

(Many more to come—let us know what your specific application is.)

NEW ACCESSORIES FOR APPLICATION FLEXIBILITY:

Now, you can control batch blending accurately on a system basis with this flowmeter and new accessories which include:

counters—permit remote digital readout; **pre-set counters**—for automatic blending; **ticket and tape printers**—allow permanent and remote recording of flow.

AND *ALL* MODELS FEATURE:

- Accuracy independent of variations in density, pressure, viscosity and temperature
- Completely self-contained, self-integrating unit
- Low pressure drop
- Accuracy unaffected by fluctuation in power supply voltage and frequency
- Long-term stability for minimum maintenance and infrequent field calibration
- Quick response to rapid changes in flow without overshoot or lag
- Measurement in pounds—eliminates tedious conversions

DO YOU HAVE AN APPLICATION for this revolutionary new instrument? Chances are you do, and we'd like to know about it. Contact your nearby G-E Sales Office, or write directly to General Electric Co., Section 599-03, Schenectady 5, N. Y. Be sure to ask for bulletin GEA-6925A. In Canada, contact Canadian General Electric Co., 940 Lansdowne Avenue, Toronto 4, Ontario. On applications in the natural gas industry, contact Black Sivalls and Bryson, Inc., P.O. Box 1714, Oklahoma City, Okla.

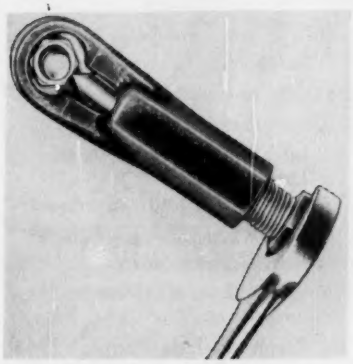
INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

(*Continued from page* 108)

wheels. It has two forward speeds (3 and 7 mph.) and can move at 3 mph. in reverse.

Clearing the ground by 4½ in., the 85-in.-long truck can execute a 180-deg. turn in a 99-in. passageway. Delivered with battery charger and cable, head and tail lights and horn as standard equipment, the truckster can also be fitted with a 2-way radio.—**Cushman Motors, Lincoln, Neb.** 108D



Nut remover

Device splits rusty nut without damage to threads or bolt.

A new "nut buster" can split and remove rusty or frozen nuts without damaging the underlying threads or bolts. In new design, head of instrument is offset from the handle to facilitate nut removal in close quarters.

Two parts comprise the tool: a cast steel hexagonal shaft has one end flattened, providing space for a round opening that fits over the nut. Running lengthwise through the shaft is a chrome-moly tool-steel bolt. It has a cutter on one end and a hex head and threads (which engage threads in the hollow shaft) on the other.

To operate, worker turns the hex head with a wrench, drives the cutter end into the side of the rusty nut. High-quality tool steel in the cutter splits the nut apart, frees it from the threads. Device is available with ¾- and 1⅛-in.

chemical processors!

get long-term reliability in your over-the-fence oxygen plant with

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CERTAINTY that in the future, as in the past, LINDE's resources permit sound expansion and unquestioned ability to meet contractual obligations. CERTAINTY that LINDE facilities can provide dependable, effective back-up for emergency needs. CERTAINTY that LINDE's resources in personnel will always provide complete creative research and technical service.

LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION

UNION CARBIDE

HOW TO AVOID DEVELOPING A COMPULSIVE DESIRE FOR A DIGITAL COMPUTER

The computer we're warning you about is called Recomp. It looks innocent enough at first. Yet one glance can be enough to arouse your acquisitive instincts. Recomp is a handsome piece of equipment. Like fine architecture or jet plane design, it looks right because it is right; form fits function.

Something else that will appeal to your practical sense is the compact size of Recomp. It's solid state, of course; in fact, it was the first fully transistorized computer on the market. There are no voluminous rows of vacuum tubes; no ventilating problems. Yet many times Recomp can match the performance of computers that literally fill rooms.

Now, to indulge your natural desire to find out more about the finest computer in its class, just imagine you have a Recomp handy. First, plug it in; any wall socket will do, and it takes no more electricity than an ordinary electric toaster. After an appreciative look at that distinctive keyboard, try a few sample problems. You will have a full scale compiler named SALT (that's Recomp's own Symbolic Algebraic Language Translator) to help you, or you can use Recomp machine language which is the simplest of any computer on the market today. If you do not know how to operate the keyboard, never mind; in a few hours you can become an expert at programming Recomp. It doesn't even demand specialized talents; anyone with computer problems can be taught to do it.

While you're enjoying yourself at the keyboard, why not try a problem using floating point arithmetic? Of course, Recomp has it built-in; in fact Recomp is the only compact computer on the market today in which this is a standard feature. It is rather astonishing how much greater capacity this gives you to handle a wide range of problems. Cuts down on that frustrated feeling.

If, at this stage, you can already feel the first stirrings of an irresistible urge to possess Recomp for your very own, let us counsel you: this is just a premature impulse. First you should read this unembellished list of facts:

1] Exclusive built-in floating point arithmetic.

2] Easy to program.

3] Efficient programming; 49 basic instructions expandable to 72.

4] Fast access time due to high-speed loops.

5] Magnetic disk memory with large capacity—up to 8192 instructions.

6] Large word length of 40 binary bits.

7] Each word contains two instructions.

8] Solid-state reliability.

9] Built-in square root command.

10] Large sub-routine and program library.

11] Active users group.

12] Built-in automatic conversion from decimal to binary.

13] Visual display of any word in memory.

14] Simple correction of errors.

15] Easily installed anywhere.

16] Can use conventional teletype equipment.

17] Low cost per computation.

18] High-speed input and output.

19] Programming training provided.

20] Large program exchange.

21] Coast-to-coast sales & service.

No doubt you have read of other computers that claim many of these advantages, but you see, Recomp is the only one that can claim them all. This can be very disquieting when you think about it.

Now, as to how you can avoid developing a compulsive desire for a digital computer: don't see Recomp in action. For on seeing the performance of Recomp, it is quite likely you will insist on owning one. However, if you find that the insidious Recomp has made an ineradicable impression on you, it would be as well to face facts. The truth is, you need Recomp. We'll be glad to help. Our address is AUTONETICS INDUSTRIAL PRODUCTS, Dept. 126, 3400 E. 70th St., Long Beach, California. **The Autonetics Division of North American Aviation, Inc.**

openings.—**Borroughs Tool & Equipment Corp., Kalamazoo, Mich.** 213A

Relief valve

Diaphragm unit seals tightly against corrosive materials.

A new diaphragm relief valve, whose spring and guides are isolated from the process fluid to avoid corrosion problems, is said to provide a tight seal against corrosive liquids and gases.

Valve body is made of Type 316 stainless steel, bronze or Hastelloy "C." Diaphragm and disk may be neoprene, stainless or Kel-F. Available with screwed or flanged connections, the line includes plain, packed and open-lever types. Mounting may be vertical or horizontal.—**Farris Engineering Corp., Palisades Park, N. J.** 215A

Packaged boiler

Small unit reaches full power quickly from a cold start.

A new line of packaged low-pressure boilers and hot-water units is known as the Cyclotherm CE. An exclusive combustion principle is guaranteed to give a minimum of 80% heat transfer efficiency.

Horizontal steam generators have central furnaces around

chemical processors!

over-the-fence oxygen plants give you a nitrogen plus with

LINDE / CERTAINTY

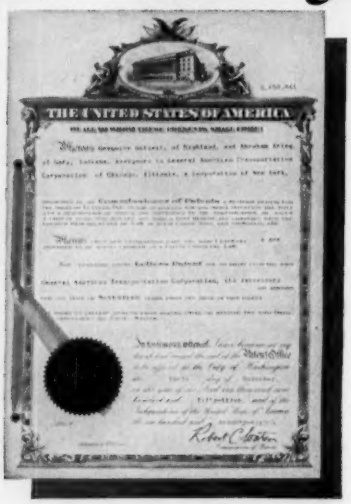
CERTAINTY that an adequate supply of nitrogen as well as oxygen will be continually available. CERTAINTY that LINDE engineering will result in the most efficient plant for economical operation. CERTAINTY that LINDE's financial arrangements will not involve your capital in any way.

LINDE COMPANY
DIVISION OF UNION CARBIDE CORPORATION

UNION CARBIDE

a Reminder

to those who use chemical nickel alloy plating:



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Kanigen®

and 29 patents prove it

There are no substitutes for Kanigen—no other process that applies a hard, corrosion-resistant nickel alloy coating without the use of electricity as Kanigen does.

With Kanigen, you can plate anything from a small relief valve to a 20,000 gallon tank car with a virtually non-porous, uniform coating.

How can you be sure of getting Kanigen? Only one way—by calling General American or one of its licensees. For further information write:

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GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street
Chicago 3, Illinois
Offices in principal cities

KANIGEN GENERAL AMERICAN

LICENSEES

INDUSTRIAL KANIGEN CORPORATION
1421 Park Avenue
Emeryville, California

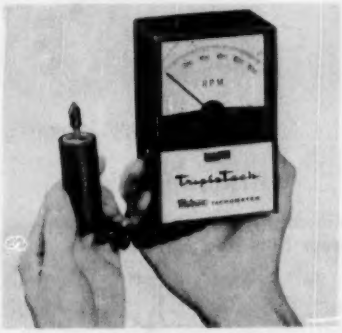
KEYSTONE CHROMIUM CORPORATION
1095 Niagara Street
Buffalo, New York

KEYSTONE METAL FINISHERS, INC.
22 Raydol Avenue
Secaucus, New Jersey

which return tubes are arranged concentrically. High-pressure units conform with the ASME Boiler Code, are stress relieved and X-rayed to meet boiler construction requirements.

The combustion system features either straight gas or combination light oil and gas units. Light oil units have pressure-atomizing nozzles with fixed capacity, delivering raw gas to the burner. Backfiring is eliminated by not premixing gas with air prior to their reaching the burner.

Both steam and hot-water generators may be supplemented with optional equipment such as automatic feedwater pump, condensate receiver tank and auxiliary heat controls.—**Cyclotherm Div., Crane Co., Oswego, N. Y.** 215B



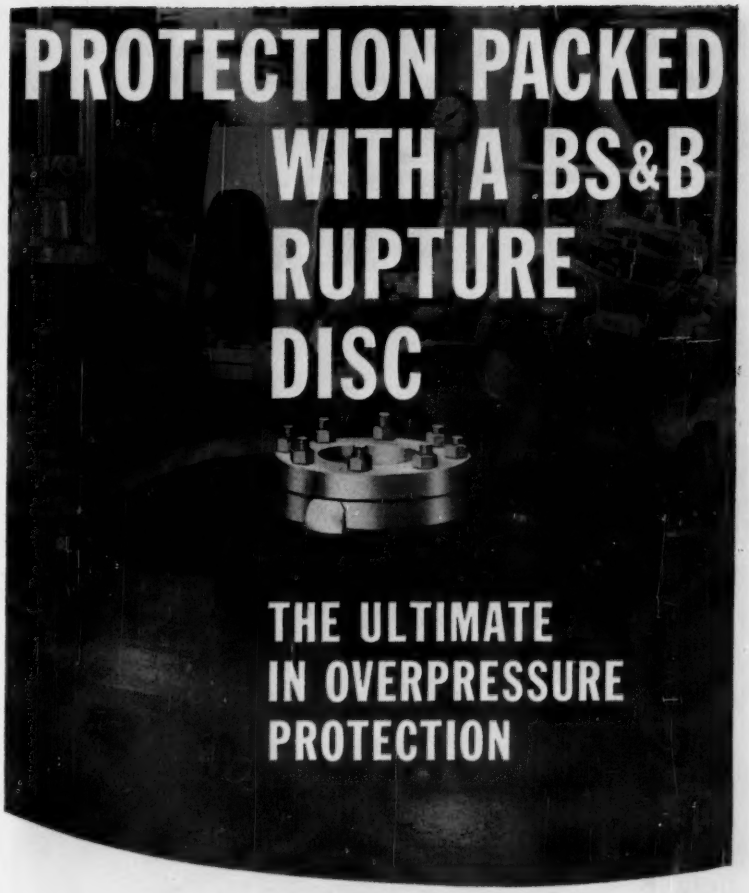
Hand tachometer

Measures speeds of shafts, belts, with range of 2 to 100,000 rpm.

This compact unit, called Tripletach, measures shaft and belt speeds over an unusually large range. A metal case holds the sealed meter movement, printed circuitry, speed pickup with retractable cord, and accessories.

Unit is available in three types having the following rpm. ranges: A, 200-10,000; B, 100-5,000; and C, 20-1,000. Three scales on the instrument, changed by a simple thumb switch, permit fine readings within these measuring ranges. Accuracy is said to be ±1% of full scale deflection.

Included among accessory equip-



If you have a pressure system equipped with a relief valve you will want this added safety measure.

BS&B Rupture Discs act fast providing an unrestricted relief opening. Discs are available in sizes ranging from ⅛" to 44" in diameter, covering rupture pressures from 3 to 100,000 PSI.

Specially engineered discs (DV) provide relief under a wide range of operating conditions including high tolerances—high temperature — pulsating pressure or alternating pressure and vacuum situations.

BS&B Rupture Discs (Safety Heads) are likewise available in a wide combination of special materials and plastics to accommodate system requirements.

Let our engineers evaluate your pressure system and help you select the proper Safety Head or write to: BLACK, SIVALLS & BRYSON, Inc., Safety Head Division, Dept. 2-N12 7500 East 12th Street, Kansas City 26, Mo.

BS&B

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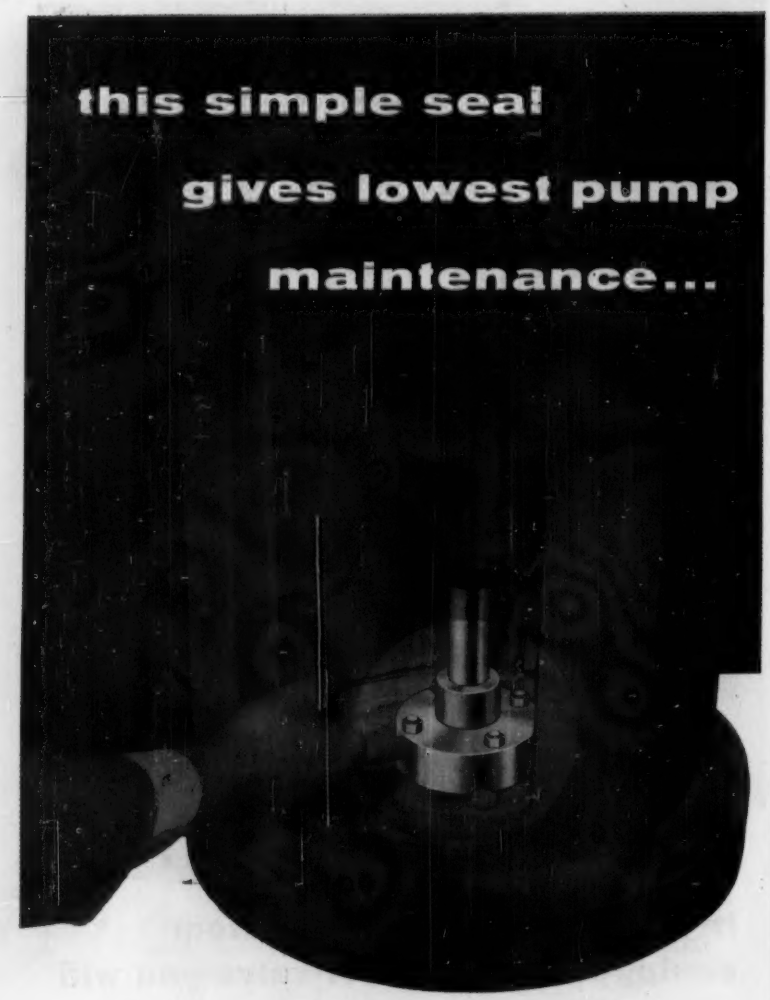
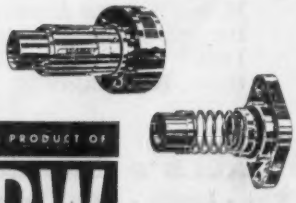
this simple seal gives lowest pump maintenance...



Save up to 66% of the time—expensive downtime—needed for installation or service of other mechanical seals used in plant process equipment.

The simple, effective Borg-Warner Type U Seal has no set screws—no close spring tension adjustments. It's fast and reliable.

For plants with a wide variety of pump service requirements, a minimum inventory of parts, and an easy change of gaskets adapts the Type U seal for service at temperatures of from —100 below zero to +650°F, and for pressures from 0 to 1000 psi.



Backed by Borg-Warner and proved in service, these dependable seals give complete safety, even in unattended stations.

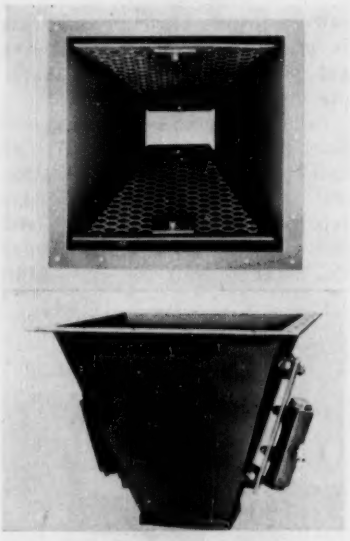
Send for the latest Type U Seal engineering information —there's no obligation.

A PRODUCT OF B-W BORG-WARNER

Borg-Warner Mechanical Seals

P.O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

ment are a carrying case, an adaptor for extending range by factors of 10 or 1/10, and a special disk for direct measurement of surface speeds. Basic unit (pickup, three tips, extension) costs $95.—**Metron Instrument Co., Denver.** 217A



Bridge breaker

Vibrating screens assure flow from bins and tank bottoms.

Solid materials that have a tendency to cake or hang up in bin bottoms get "all shook up" by a new bridge breaker. Mounted inside the bin, parallel to the walls, expanded metal screens vibrate without shaking the bin or other equipment.

Vibrators mounted on the outside walls of the bin transmit vibration to the screen with shock-mounted studs that pass through the walls. The motion of the screens is always parallel to the sides of the bin, hence screen action does not tend to compact the solid material.

Screen sections are available for either flat or conical surfaces in areas up to 4 sq. ft. Screens are of carbon steel for most applications; for handling special materials, stainless steel construction is offered.—**Thayer Scale Corp., Pembroke, Mass.** 218A

CUT FUEL BILLS 20% WITH A LJUNGSTROM® AIR PREHEATER

The world's largest fluid catalytic cracker at Esso's Bayway Refinery is equipped with a new Ljungstrom Air Preheater. This picture shows the half-ton cold-end elements being installed in the Ljungstrom rotor.

Your biggest refinery operating expense is the money you burn: fuel costs. You can chop fuel bills ⅓ with a Ljungstrom Air Preheater, and here's how:

Your fuel bill drops about 1% for every 45-50°F you raise the temperature of combustion air. Ljungstroms now in service raise the air temperature 1000°F or more – and the rest is simple arithmetic. With a Ljungstrom, four barrels of fuel do the work of five. On fuel savings alone, one eastern refinery came up with net savings of $67,800 in the first year they used a Ljungstrom.

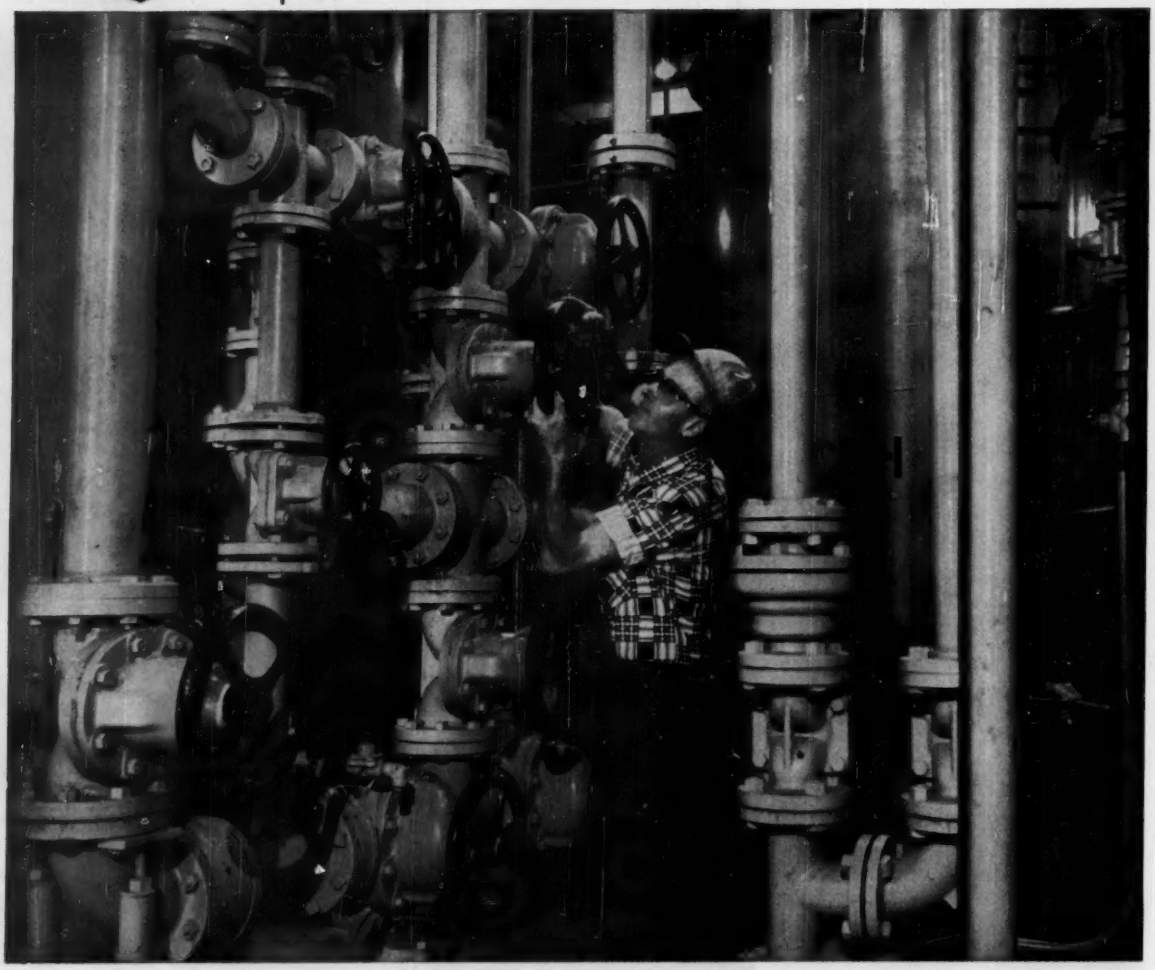
SAME FUEL, MORE HEAT. Ljungstrom economy is flexible economy. If total throughput is more important to you than fuel savings, a Ljungstrom can help boost the capacity of a pipe still at least 10% a day, without any increase in fuel consumption.

THESE ARE FACTS backed up by 25 years of Ljungstrom performance in refineries all over the world. But they're not the only facts. To find out about Ljungstrom's low-cost maintenance, easy inspection, in-service cleanability, space-saving compactness, call or write The Air Preheater Corporation for a free copy of a brochure called "The Ljungstrom Air Preheater for Process Equipment."

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

DOW | **SARAN LINED PIPE**



5 miles of pipe, 12 years of service

Saran Lined Pipe keeps process acids flowing!

When five miles of process piping must carry an unfailing flow of highly corrosive acids, thorium salt solutions and slurries . . . when frequent flow changes require quick, on-the-spot pipeline modifications . . . that's when the extreme corrosion resistance and easy workability of Saran Lined Pipe make this process pipeline a process lifeline.

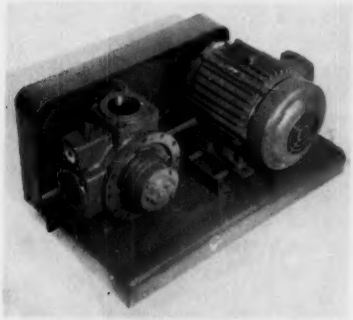
Above is one section of the approximately five miles of Saran Lined Pipe which carries process chemicals in thorium recovery operations at the American Potash & Chemical Corporation's Lindsay Chemical Division plant, West Chicago, Illinois. In this process, Saran Lined Pipe is required to carry highly corrosive materials: sulphuric acid slurries for ore leaching; reacted thorium sulphate solutions and waste slurries; concentrated hydrochloric acid, hydrofluoric acid slurries. The pipe network has been in constant use since 1947, and *there's never been a major process shutdown because of pipeline failure!*

Equally as important to Lindsay as corrosion resistance are the workability and strength of Saran Lined Pipe. The nature of the process requires frequent flow changes, meaning frequent changes in piping. Necessary pipeline modifications are done quickly and easily by plant personnel, cutting process downtime to a matter of hours. And high physical strength of the pipe minimizes the need for extensive pipe supports!

Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200°F. They can be cut, fitted and modified easily in the field without special equipment. For more information, write Saran Lined Pipe Company, 2415 Burdette Ave., Ferndale, Michigan, Dept. 2283AK12-12.

See "The Dow Hour of Great Mysteries"

THE DOW CHEMICAL COMPANY · MIDLAND, MICHIGAN



Vane pump

Free-floating rotor gives higher pressure and greater capacity.

Called Coro-Vane, a new pump achieves higher differential pressures and greater capacity than its predecessor because it is machined to closer clearances. Pump contains a free-floating rotor and shaft assembly that finds its own center.

Coro-Vane is a positive-displacement type with hydraulically actuated vanes of plastic, carbon or other materials. Pump materials include ductile iron, stainless steel and aluminum. Unit, available in a range of models and sizes, handles both volatile and nonvolatile liquids under high pressure.—**Corken's Inc., Oklahoma City, Okla.** 221A

Briefs

Roller mill system will grind for pilot plant and small production, or serve as a grinding test stand. System includes feed elevator and bin, mill with 2 or 3 rolls, product bin, dust collector and control panel. Capacity: about 3 tons/hr.—**Bradley Pulverizer Co., Allentown, Pa.** 221B

Aluminum handrail provides a complete installation with three post designs. Accommodating any stair angle, railing can be erected on the site with a hacksaw, drill and small wrench. Available in natural aluminum finish or in color.—**Aluminum Co. of America, Pittsburgh.** 221C

ATTENTION!!! NEW PRODUCT PLANNERS: NEW USES FOUND FOR UNIQUE PROPERTIES OF METALLIC OXIDE PIGMENTS

You ordinarily think of metallic oxide pigments being used to produce coloring agents, catalysts, polishing agents and magnetic materials. Today, however, new product planners and production engineers are finding that uses for the unique physical and chemical properties of metallic oxides are surprisingly far afield from traditional usages.

Below is a review of their characteristics. Look them over. You may get the germ of an idea which will lead you to the improvement of existing products, or to the reduction of new product manufacturing costs. Should an application suggest itself . . . let us know. We'll be glad to cooperate with you in exploring the possibilities. Address Department 62, C. K. Williams & Co., 640 N. 13th St., Easton, Pennsylvania.

NAME	PROPERTIES
Pure Red Iron Oxides	Fe_2O_3-99.5% SpG.-5.15 Color—Salmon to purplish red
Pure Yellow Iron Oxides	$Fe_2O_3H_2O$-99% SpG.-4.03 Color—Lemon to dark orange
Pure Black Iron Oxides	Fe_3O_4-96% min. SpG.-4.96 Color—Blue Black
Pure Chromium Oxides (and Hydrates)	Cr_2O_3-99% SpG.-5.20 Color—Light to dark green
Natural Oxides—Ochers, Umbers, Siennas, Metallic Browns, Red Oxides	Wide range of ferric oxide content and red, yellow and brown colors
Venetian Reds	Fe_2O_3-40% SpG.-3.45 Color—Light to medium red
Cuprous Oxide	Cu_2O-97% min.
Extenders—Barytes, Calcium Carbonate, Calcium Sulfate, Silica	Wide range

Composition: The basic colors of the iron and chromium oxides are determined by chemical composition. Reds are ferric oxide (Fe_2O_3); yellows, hydrated ferric oxide ($Fe_2O_3.H_2O$); blacks, ferro-ferric oxide (Fe_3O_4); and greens, chromic oxide (Cr_2O_3). All these compounds are chemically stable and light permanent.

Particle Shape: Physical properties such as oil absorption and suspension characteristics are dependent on particle shape, controlled by manufacturing processes.

Size: Color range is controlled by particle size—average size increases as color darkens. Uniformity of size determines brightness.

Purity: Freedom from impurities is essential for superior pigment properties and to prevent deleterious effects in end-products. Control of soluble salts, manganese and copper content are an important part of the Williams' manufacturing operation.

C. K. WILLIAMS & CO.
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"Pigment Technology at its best"

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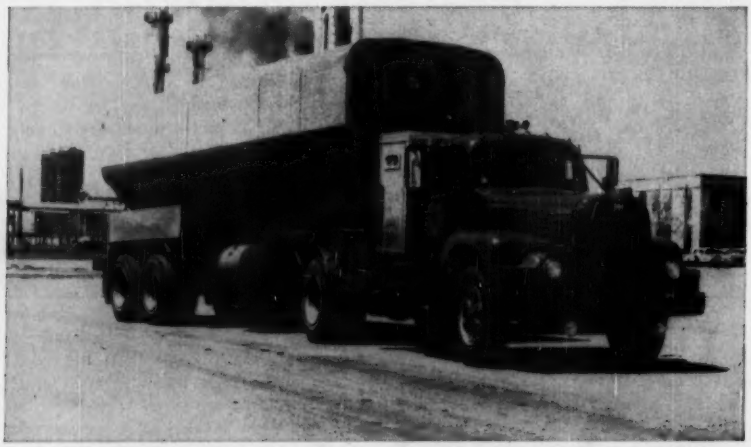
Pointers

for Mixing and Blending • Size Reduction • Pelleting and Densifying • Size Classification • Bulk Materials Handling

Published in the interest of better processing by Sprout, Waldron & Co., Inc., Muncy, Pa.



One of five Sprout-Waldron Pneumatic Aluminum Bulk Trucks for handling polystyrene pellets in Cosden Petroleum's new "curb service marketing" delivery concept. Note Cosden's modern 32,000 barrel custom refinery in background.

SPROUT-WALDRON BULK TRUCK HANDLES POLYSTYRENE PELLETS

A recent announcement by officials at Cosden Petroleum Corporation, Big Spring, Texas of a new delivery concept, "curb service marketing" is arousing considerable interest throughout the plastic industries. The revolutionary marketing plan involves a delivery of polystrene pellets by special highway transports direct from the purchasing plant to the customer.

The key to the new concept is a group of five 28' pneumatic aluminum bulk trailer units designed and built by Sprout-Waldron. Each of these trailers has a capacity of 1,182 cubic feet which is equivalent to 34,000 lbs. of polystyrene pellets. The high powered unloading system permits delivery to the customer at the rate of 30 tons per hour. Delivery and storage in bulk cuts down on fringe expenses such as unloading, warehousing, multiple handling and contamination. Bulk storage also permits instant inventory determination. Storage bins can be located at the most suitable point in the plant since the pneumatic unloading system built into the trucks permits delivery anywhere a pipe can be run.

Recent completion of the new polystyrene plant is said to make Cosden Petroleum the first producer able to integrate all phases in the manufacture of this basic material. Both general purpose crystal polystyrene and high impact polystyrene are being produced. The styrene monomer used in manufacturing polystyrene is produced in an adjacent plant also owned and operated by Cosden.

For more information on how Sprout-Waldron pneumatic bulk trucks may fit your application, write for Bulletin 205.

COP/102

NEW EQUIPMENT . . .

Trace oxygen analyzer will measure as little as 0.3 ppm. oxygen in gases such as argon and nitrogen. Measurement is made by an electrolytic cell that generates a voltage proportional to the amount of oxygen present over the electrolyte. Analysis is recorded continuously.—**Thermco Instrument Corp., La Porte, Ind.** 222A

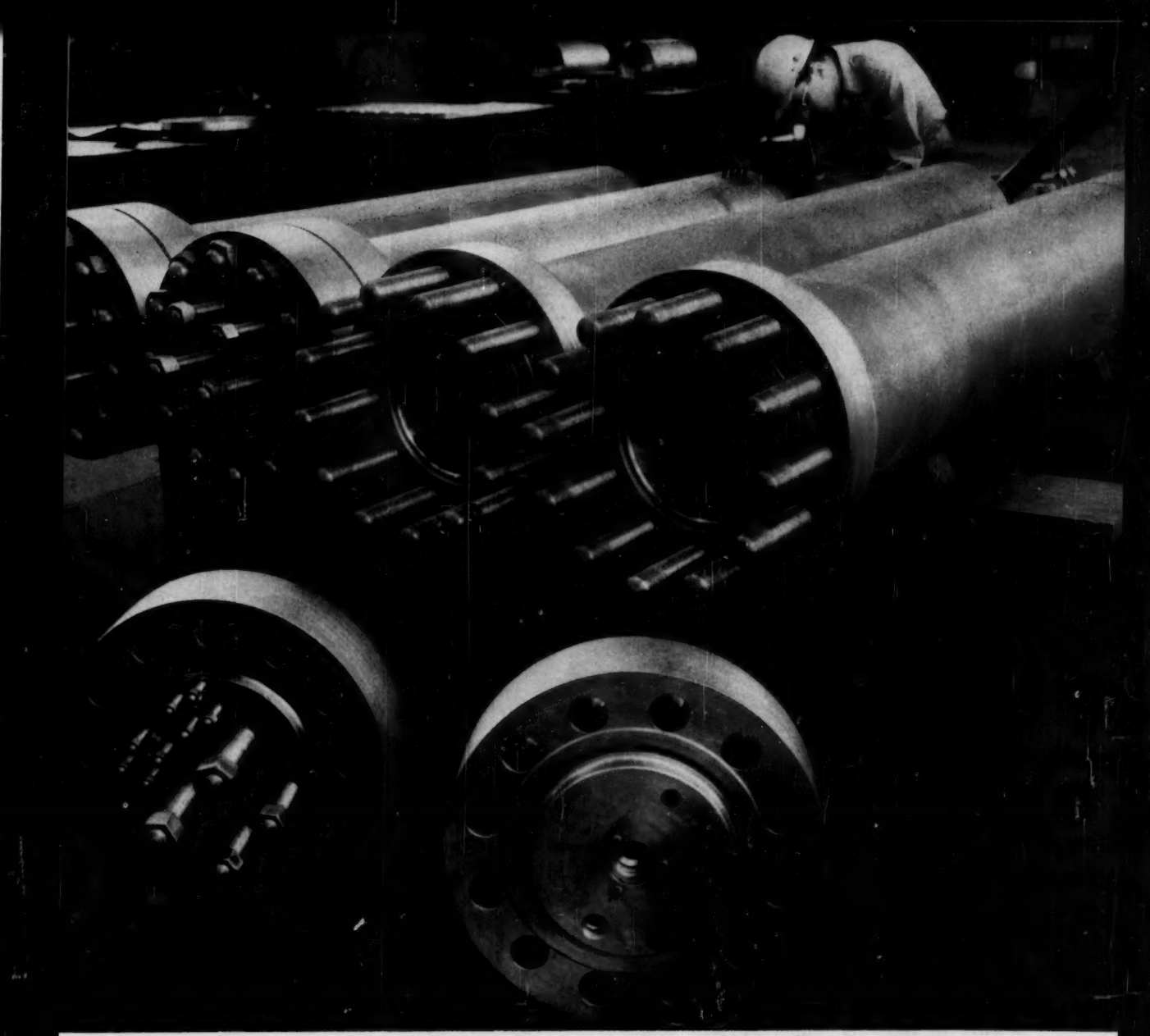
Expanded silica insulation, reinforced with an inorganic fiber, can be used for all applications to 1,600 F. Called Careytemp, insulation is resistant to water and acids, can be cut in thin sections without crumbling. With a vapor barrier jacket, it can also be used for cryogenic applications.—**The Philip Carey Mfg. Co., Plymouth Meeting, Pa.** 222B

Filter and strainer clarify any fluid containing foreign particles. Two filters, mounted together with three-way valves, may be operated alone or together, may be backwashed and blown down on the run. Rated 5 to 150 gpm., to 200 psi.—**Ronningen-Petter Co., Vicksburg, Mich.** 222C

Equipment Cost Indexes . . .

	June 1960	Sept. 1960
Industry		
Avg. of all	238.2	237.4
Process Industries		
Cement mfg.	232.8	231.7
Clay products	226.2	225.6
Glass mfg.	226.6	225.3
Paint mfg.	229.8	229.1
Paper mfg.	231.3	229.9
Petroleum ind.	234.1	234.0
Process ind. avg	236.5	236.2
Rubber ind.	237.6	236.9
Related Industries		
Elec. Power equip	242.7	240.2
Mining, milling	241.5	240.0
Refrigerating	268.5	267.7
Steam power	225.0	224.3

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124-6 for method of obtaining index numbers; April 4, 1960, pp. 149-50 for annual averages since 1913.



These separators were tested at 9,000 psi

Almost ready for shipment to a chemical plant, these separators weigh about 2½ tons each. They measure 10 ft in length, and their inside diameter is 12 in. They were checked out with a hydrostatic test of 9,000 psi before they were okayed for shipment.

Every Bethlehem forged vessel—whether it tips the scale at 150 tons or 900 lb — has the same rugged look about it. Even the most minor components are designed for long, heavy-duty service.

If you are planning new autoclaves, converters, separators, filters, reactors, or accumulators, we suggest you discuss matters with our engineers. They will gladly help plan the types and sizes of vessels that meet the requirements of your process.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

Export Sales: Bethlehem Steel Export Corporation

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FLEXIBILITY of operation, providing ANY COMBINATION of products, liquid or high pressure gas PLUS simultaneous production of BOTH oxygen and nitrogen delivers maximum yield of combined products at minimum cost of operation with little operator's attention. Packaged design requires minimum of installation cost and space.

This most modern and efficient design from Independent combines the best features of the earlier two-product package plants pioneered by Independent with the latest concepts of external refrigeration. Type illustrated in 1500 to 5500 cu. ft. per hour capacities. Other types in larger and smaller sizes. Pure argon available on larger sizes.

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Technical Bookshelf

PERSONNEL SEDUCTION

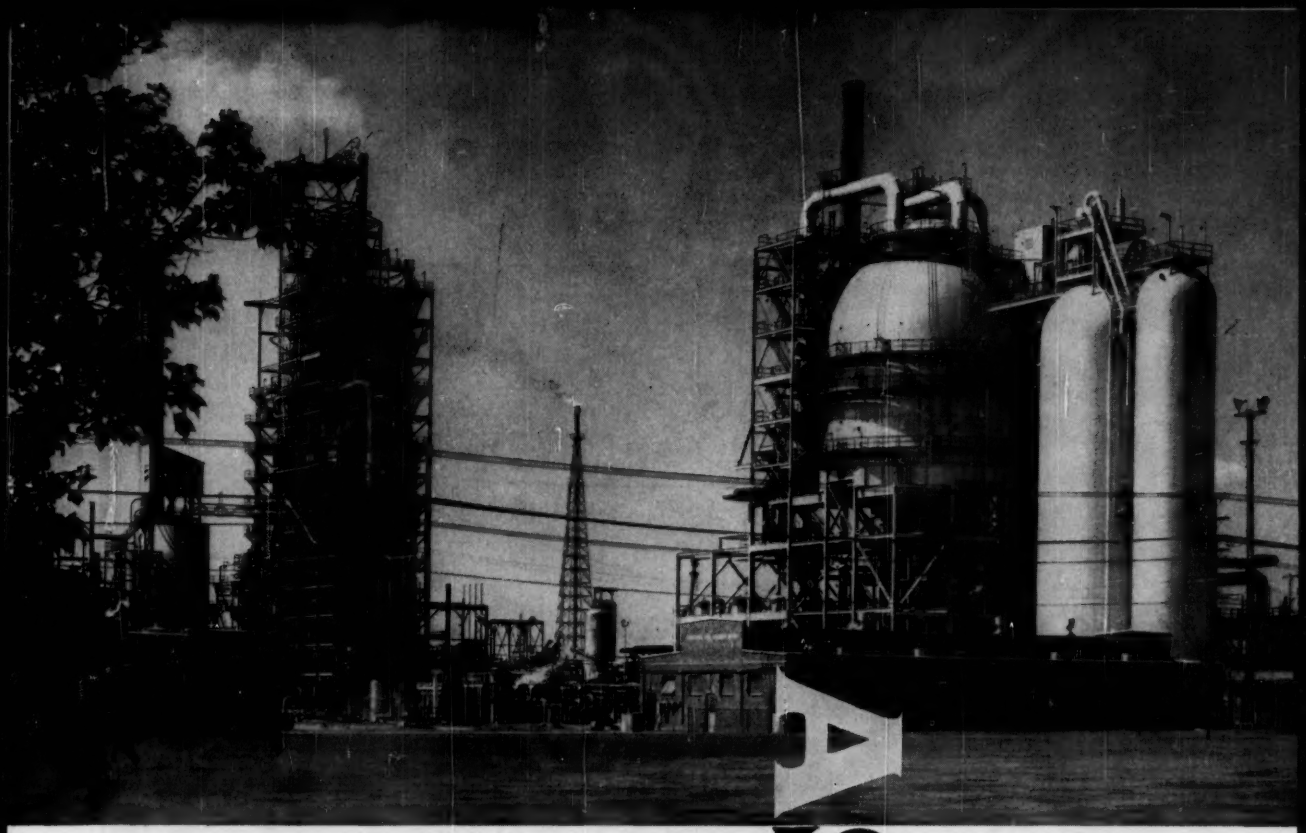
EXECUTIVE RECRUITING—How Companies Obtain Management Talent. Executive Reports Associates. Box 375, Lake Forest, Ill. 105 pages. $12.50.

Professor Georges F. Doriot's course at the Graduate School of Business at Harvard has come up with another fascinating study on a controversial aspect of American business. Last year, it produced a report on competitive intelligence (i.e., industrial spying); this year, a report on a phase of executive recruiting (i.e., pirating). Starting with the premise that the hiring of top executive talent is becoming increasingly difficult, this 105-page study proceeds to examine the many factors involved in luring a man from one top job to another.

To simplify the definition of "executive," the report specifically excludes engineers and other technical personnel from the scope of its research. But corporate officers, division managers and major department heads all come under the executive label, and there is much that applies to the operations of chemical processing companies. The authors interviewed over one hundred high-level industry executives, leading management consultants and executive recruiters, to secure raw material for this report. Completed questionnaires from 116 company presidents supplemented the interviews.

The report concludes that the underlying causes of increasing executive mobility are errors in selection, increasing complexity of the business world, decreasing company loyalty on the part of professional managers, and the rise of professional recruiters. Although there are many recruiting avenues available to a company, there appears to be an increasing reliance on professional recruiters —who take an average of two or three months to find the right man, collect from the company 10-25% of the job salary as fee.

Opinions as to the ethics of pirat-



Low cost, excellent resistance to corrosion:

FEDERATED CHEMICAL LEAD sheet, pipe, fittings, linings

Federated lead products are self-healing; malleable, easy to form and bend; salvable with high scrap value; and probably the most efficient protection you can find for many corrosive chemical conditions. These products include chemical lead sheets to your requirements; pipe, bends, traps and standard fittings available from stock; special forms fabricated to order. Write for Bulletin No. 162, the Lead Handbook for the Chemical Process Industries, to Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, RE 2-9500; or call your nearest Federated sales office.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

FEDERATED METALS DIVISION

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ALTON, ILLINOIS
Alton: Howard 5-2511
St. Louis: Jackson 4-4040

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Orleans 5-2400

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Fairfax 2-1802

BOSTON 16, MASS.
Liberty 2-0797

CHICAGO, ILL. (WHITING)
Chicago: Essex 5-5000
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Cherry 1-1678

CLEVELAND, OHIO
Prospect 1-2175

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Adams 5-5034

DETROIT 2, MICHIGAN
Trinity 1-5040

EL PASO, TEXAS
(Asarco Mercantile Co.)
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Angelus 8-4291

MILWAUKEE 10, WIS.
Hilltop 5-7430

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PHILADELPHIA 3, PENNA.
Locust 7-5129

PITTSBURGH 24, PENNA.
Museum 2-2410

PORTLAND 9, OREGON
Capitol 7-1404

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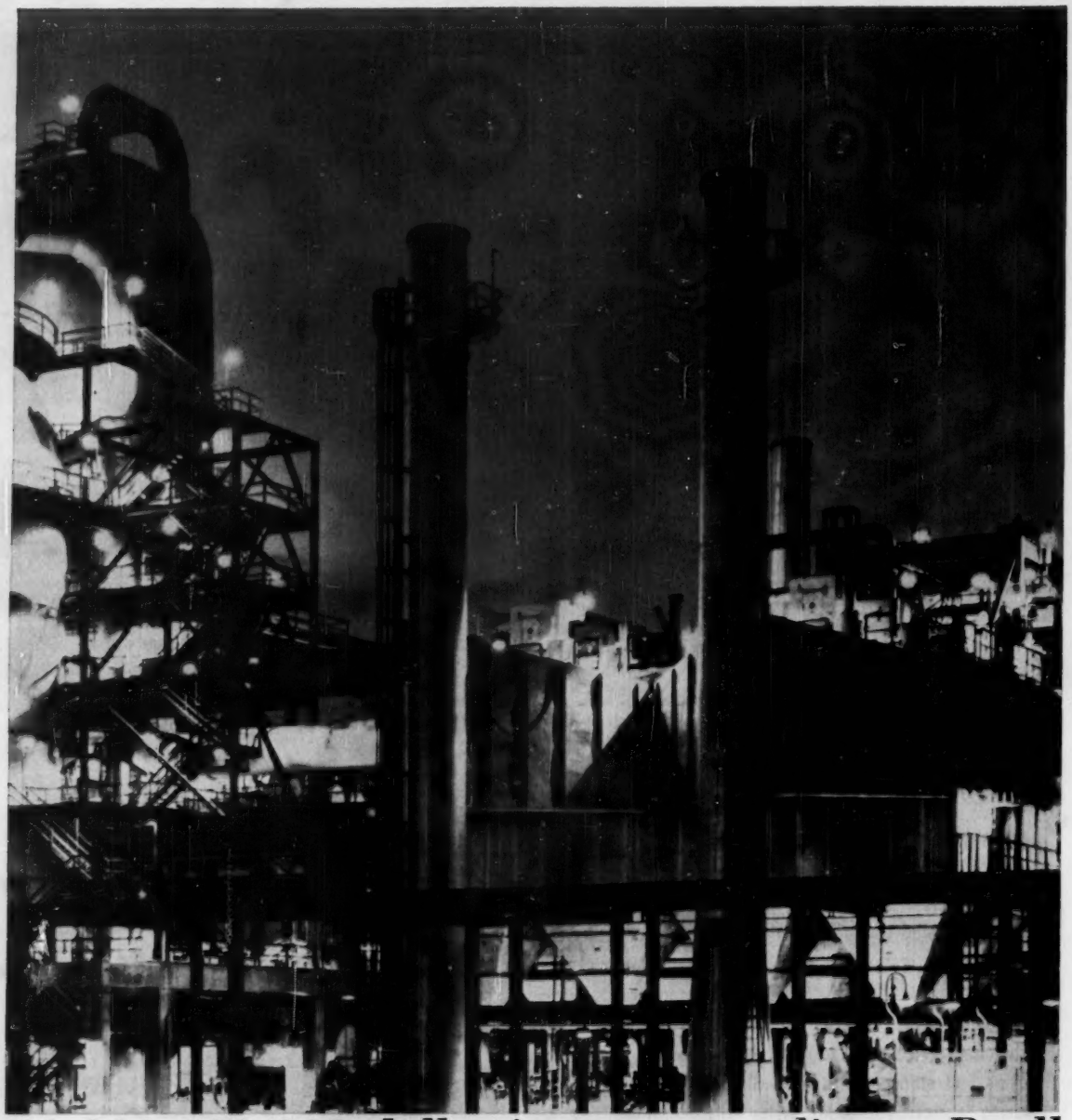

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ing vary from "anything goes in business," to checking with a man's supervisor before making an offer; the former attitude seems more prevalent. The best defense against pirating, according to the study, is an active management development program that makes the present managers feel there is opportunity for them within their own company. Such a program also furnishes ready replacements for any man who might leave—RAL

ALL OUT FOR THE JOB HUNT

THE RIGHT APPROACH—For Job Searchers. By E. A. Butler. Business Consultants Publishing Co, 510 Madison Ave., New York, N.Y. 85 pages. $3.15.

In what might best be described as a bookette (hard-cover, 7¼" x 4¾", 85 pages, large type) a consultant gives advice on effective job-getting.

This is very fast reading and some of it is quite worthwhile. Particularly interesting (but not detailed enough) are sections on nepotism, the fear of psychological testing, office politics. For higher-echelon personnel, there's a discussion of stock options. Many hints are given the green applicant on how to present both himself and his resume. Book price is too high for so short a work but, then again, someone could suggest: What's $3.15, when thousands might be at stake?—HSG

Continuing our listing of booklets and miscellaneous from last issue, here are five more entries:

1. *Proceedings of the Fourteenth Industrial Waste Conference* (May 5, 6 and 7, 1959). Engineering Bulletin of Purdue University. Vol XLIV, No. 5—Engineering Extension Series No. 104. The proceedings are here presented in an 832-page soft-cover that includes all but two of the 58 papers given. Cost: $3.50. Write to Engineering Bulletin, Purdue University, Lafayette, Ind.

2. *Duolite Ion-Exchange Manual.* Basic information on properties and uses of ion-exchange resins. Treats laboratory procedures, lists applications (via description of

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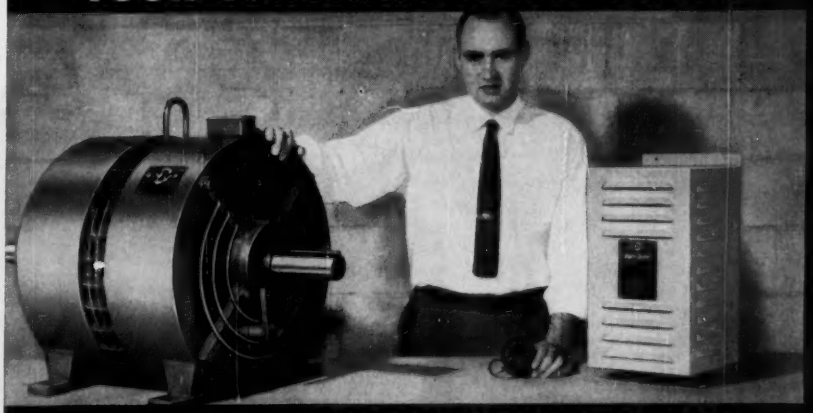

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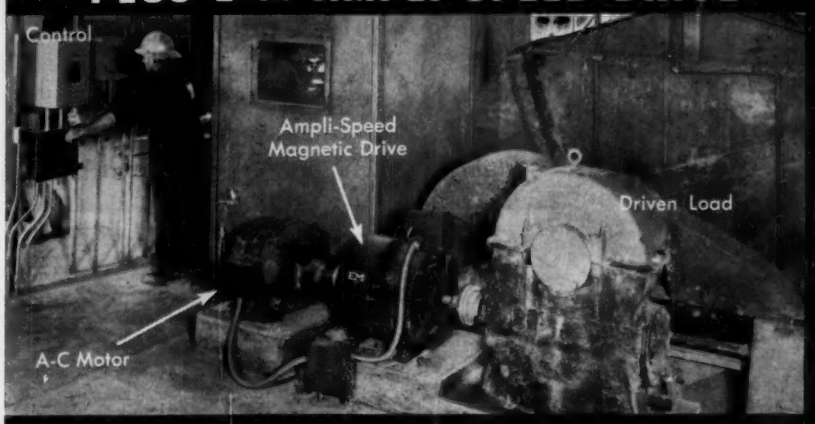

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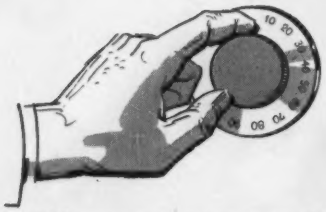

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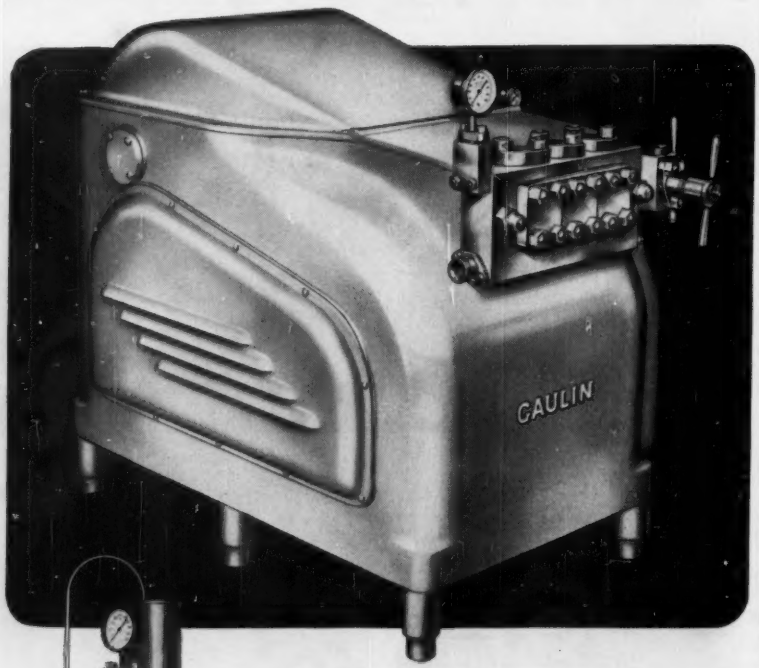

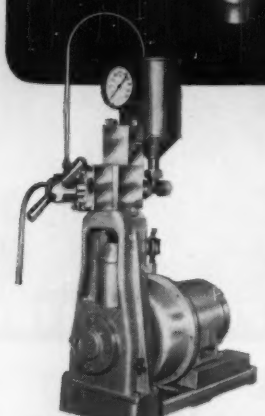

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patents). Requests for single copies to: Dr. I. A. Abrams, Chemical Process Co., 1901 Spring St., Redwood City, Calif.

3. *National Fire Codes, 1960-61.* 7 vols., 5,614 pages. The National Fire Protection Assn. has issued a revised edition of its fire code safety standards. Volumes' contents are: 1. Flammable Liquids and Gases; 2. Combustible Solids, Dusts, Chemicals and Explosives; 3. Building Construction and Equipment; 4. Fixed Extinguishing Equipment; 5. Electrical; 6. Transportation; 7. Mobile Fire Equipment, Organization, and Management. Cost: $7 per volume; $40 for all seven. Write: Publications Dept., National Fire Protection Assn., 60 Batterymarch St., Boston 10, Mass.

4. *Chemical Titles,* a new ACS publication, will issue as of January, 1961. The twice-monthly index will cover 575 journals. To use it: one column presents subject matter alphabetically, next column gives index reference. Going to index reference, you get author's name, full title, source, year, page number of article in question. Base rates vary. Highest (for nonacademic, nonmembers, single subscription) is $65, annually. For all details, contact: American Chemical Society. Attn: R. H. Belknap, Business Manager, 1155 Sixteenth St., Wash. 6, D. C.

5. *Current Contents of Space and Physical Sciences* will be a weekly listing of articles in these fields. Over 425 periodicals will be covered, including foreign ones. And, publisher states that over 50% of the articles listed will be in advance of original publication. A companion work to *Current Contents of Chemical-Life Sciences,* publication will begin as of January, 1961. For specimen copy and details, write: Institute for Scientific Information, 1122 Spring Garden St., Philadelphia 23, Pa.

In Rapid Review

Photochemistry in the Liquid and Solid States. Ed. by L. J. Heidt, R. S. Livingston, E. Rabinowitch and F. Daniels. John Wiley & Sons, New York. 174 pages. $6. Various phases of

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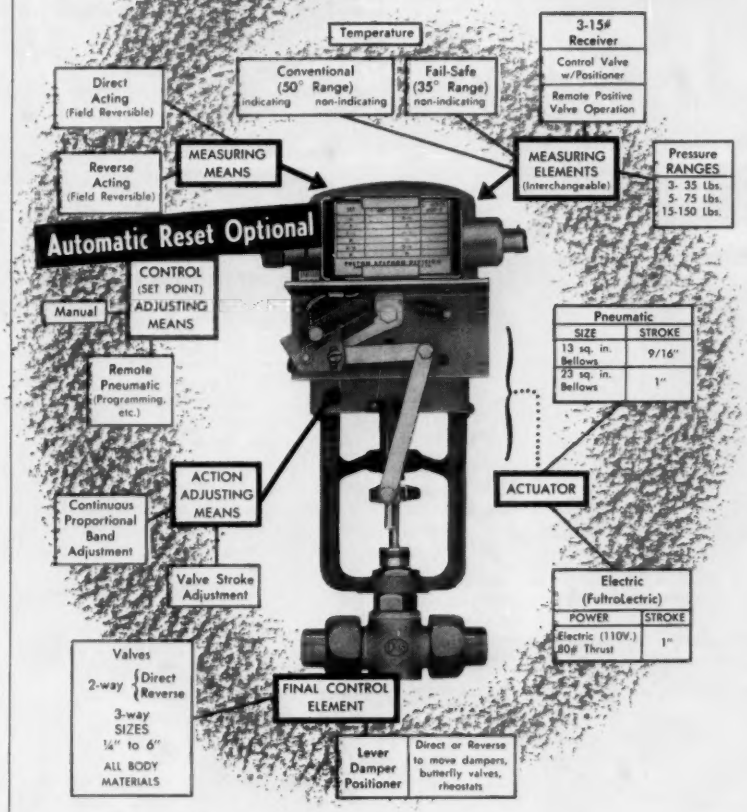

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photochemistry in the liquid and solid state, such as photochemical reactions, photosensitized reactions, fluorescence, the role of the triplet state and reactions involving chlorophyll are discussed in this collection of 26 papers. This book, based on a symposium sponsored by the National Academy of Science and the National Research Council to investigate the practical utilization of solar energy, presents a broad survey of the field and suggests areas for further research. It is of definite value to a new investigator.

Frozen Free Radicals. By G. J. Minkoff. Interscience Publishers, New York. 148 pages. $5. A brief, basic treatment for the newcomer. Early history is reviewed. Experimental methods are given for the production and detection of radicals. Trapping of free radicals is discussed first in terms of basic principles and requirements, then by separate chapters on individual atoms, di- and triatomic radicals, and polyatomic radicals containing carbon.

Mechanical Properties of Intermetallic Compounds. Ed. by J. H. Westbrook. John Wiley & Sons, New York. 435 pages. $9.50. Proceedings of an international symposium sponsored by the Electrochemical Society in 1959. Contains a review of the literature (55 pp., 164 ref.), two papers on electronic and thermal factors in mechanical strength; information on experimental techniques for high-temperature tensile and torsional testing, fractography and extrusion; four papers on the effects of dislocations and point defects; and detailed data on the properties of TiA1, InSb, transition-element beryllides, Cu-A1, Fe-Ni, NiA1 and $NiA1_3$.

Physical Methods in Chemical Analysis. Vol. 1, 2nd rev. ed. Ed. by W. G. Berl. Academic Press Inc., New York. 686 pages. $19. This second edition was necessitated by the rapid advances that the last ten years have seen in the development of analytical instrumentation. Techniques discussed are the same as those in the first edition, namely, methods dealing with the interaction of radiation with matter. The pattern of chapter presentation involves a brief survey of working theory, a discussion of available instrumentation, methods of determination, applications and a valuable reference list.

An Introduction to the Chemistry of Heterocyclic Compounds. By R. M. Acheson. Interscience Publishers, Inc., New York. 342 pages. $5. A well-written discussion of the basic heterocyclic systems using modern electronic and mechanistic concepts. The book has a bibliographical and reference

Carl G. Paulson, Director of Hayes Research and Development Group, Reports...

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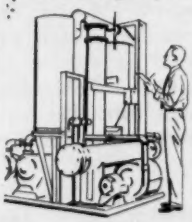

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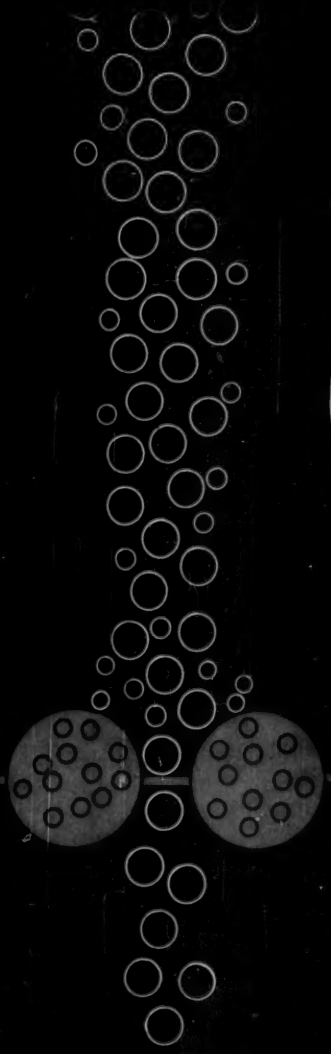

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section (with references up to 1960) at the end of each chapter as well as subject and compound indexes, is profusely illustrated with clear structural diagrams.

The Photoconductivity of Solids. By R. H. Bube. John Wiley and Sons, New York. 461 pages. $14.75. The phenomenon of photoconduction has been known for 87 years, is employed today in television cameras, rapid copying processes and control devices for research and industrial instruments. This book is the first full text offering an analytical approach to the phenomenon in compounds as well as elements. Subject is treated as a logical extension of existing semiconductor research, the difference being the larger energy gap involved in the photoconductive process. Text ranges from elementary theoretical concepts to the formal treatment of effects in real compounds, includes the real phenomena of electrode effects, sensitization, imperfection effects.

Substitution at Elements Other Than Carbon. By C. K. Ingold. Interscience Publishers, New York. 52 pages. $3.50. A group of lectures dealing with nucleophilic substitution at octahedral metal atoms (in particular, cobalt) and electrophilic substitution at nitrogen and oxygen (nitration and nitrosation). The author suggests that the methods applied to the study of mechanism in organic chemistry might serve as a model in a similar study of inorganic chemistry.

Crystal Structures, Supplement V. By R. W. G. Wyckoff. Interscience Publishers, New York. 470 pages. $26.50. The publication of Supplement V marks the completion of Wyckoff's series: "Crystal Structures." The series, organized as five volumes to be kept in loose-leaf binders, describes both inorganic and organic compounds. Supplement V contains 470 pages of text, tables, illustrations, bibliography and indices, which are to be incorporated into the five present volumes or are to replace previously issued pages. The nature of the material of Supplement V is such as to render it essential to the usefulness of the series.

Medicinal Chemistry, 2nd ed. Ed. by A. Burger (and collaborators). Interscience Publishers, New York. 1,243 pages. $37.50. In the present edition, the editor has enlisted the assistance of 34 experts in various fields of medicinal chemistry who report on their specialties. By careful planning, paring and adding, the physical size of the 1960 text has only grown by 20%. Probably the most authoritative accounting of medicinal chemistry in our times.

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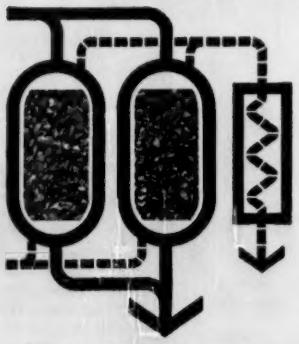

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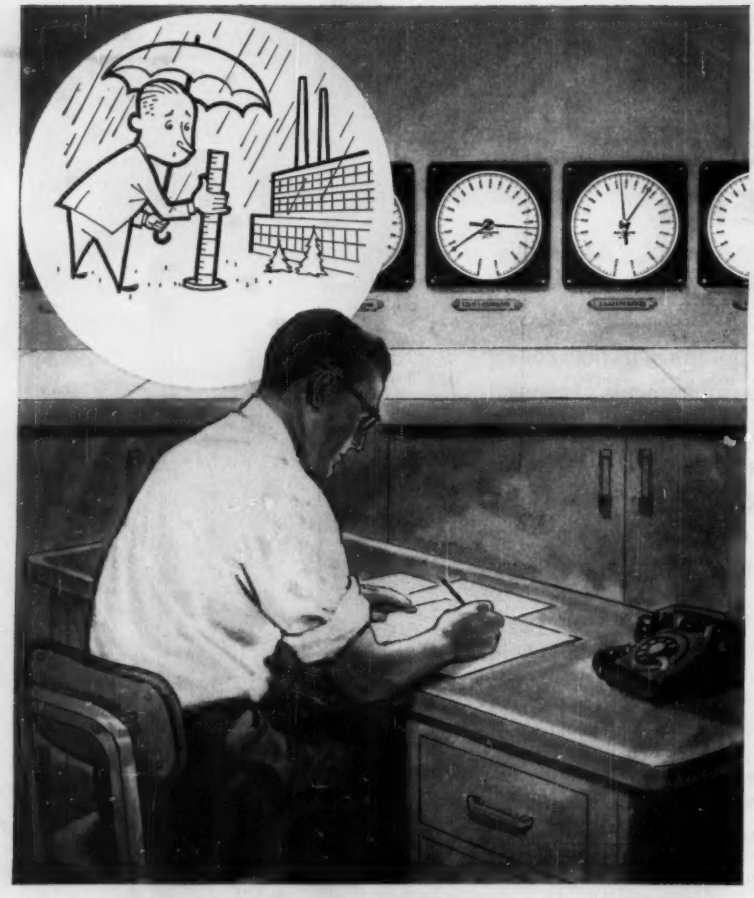

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Annual Reports on the Progress of Chemistry. Vol. LVI, 1959. Ed. by R. A. Cahn. The Chemical Society (London). £2, post free.

Progress in Inorganic Chemistry. Ed. by F. A. Cotton. Interscience. $10.50.

Industrial Electric Furnaces and Appliances. 2nd ed.; rev. By V. Paschkis and J. Persson. Interscience. $24.

Lipide Metabolism. Ed. by K. Bloch. Wiley. $10.50.

Science Survey—1. Ed. by A. W. Haslett and J. St. John. Macmillan. $5.75.

Temperature Measurement and Control. By W. F. Coxon. Macmillan. $12.

Corrosion Problems of the Petroleum Industry. Macmillan (and Soc. of Chemical Industry, London). $6.

Oceanography and Marine Biology. By H. Barnes. Macmillan. $7.50.

The Physics of Flow Through Porous Media. Rev. ed. By A. E. Scheidegger. Macmillan. $15.50.

Vitality in a Business Enterprise. By F. R. Kappel. McGraw-Hill. $4.

Physical Methods of Organic Chemistry—Part III. 3rd ed. Interscience. $24.50.

Introduction to Semimicro Qualitative Analysis. 3rd ed. By C. H. Sorum. Prentice-Hall. $3.50.

Transport Phenomena. By R. B. Bird, W. E. Stewart, E. N. Lightfoot. Wiley. $13.75.

The Chemistry and Technology of Fertilizers. Ed. by V. Sauchelli. Reinhold. $18.

Isotope Effects on Reaction Rates. By L. Melander. Ronald. $6.

Introduction to Textiles. By E. E. Stout. Wiley. $6.50.

Embrittlement by Liquid Metals. By W. Rostoker, J. M. McCaughey, H. Markus. Reinhold. $7.95.

A History of the Theories of Aether & Electricity. By Sir Edmund Whittaker. *Vol. 1: The Classical Theories. Vol. 2: The Modern Theories.* Harper Torchbooks. Vol. 1: $1.95; vol. 2: $1.85.

Accelerators: Machines of Nuclear Physics. By R. R. Wilson and R. Littauer. Doubleday Anchor. 95¢.

Pasteur and Modern Science. By René Dubos. Doubleday Anchor. 95¢.

Organic Reactions. Vol. XI. Ed. by A. C. Cope, et al. Wiley. $12.

Nash Compressors Tame "Hard-to-handle" Corrosive Gases

The reasons for the success of Nash Compressors in handling "dirty" and corrosive gases are simple. First, Nash Compressors have no internal parts in wearing contact, or requiring close tolerances and internal lubrication. Second, because of the Nash operating principle, a variety of liquids can be employed as the compressant medium, protecting the interior from corrosive action. Third, the pump casing may be fabricated from a variety of special metals and alloys. That is why Nash Compressors take these rugged jobs in stride.

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HEXANE
HELIUM
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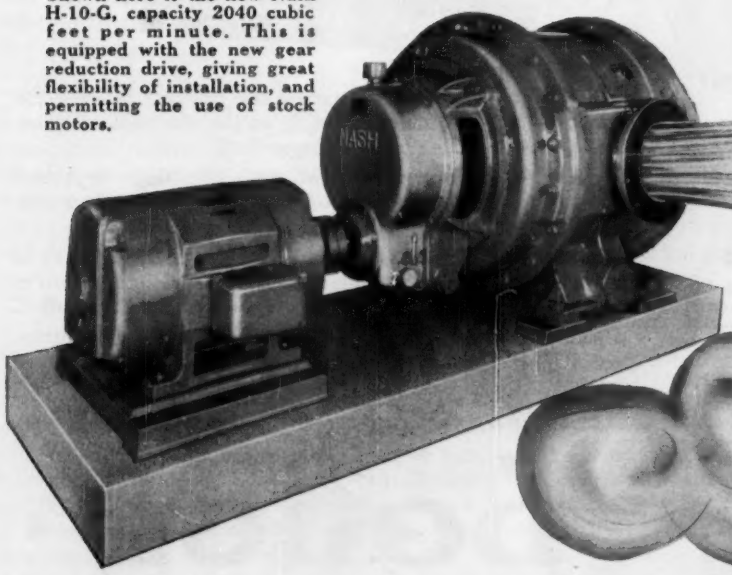
AND MANY OTHERS

Shown here is the new Nash H-10-G, capacity 2040 cubic feet per minute. This is equipped with the new gear reduction drive, giving great flexibility of installation, and permitting the use of stock motors.



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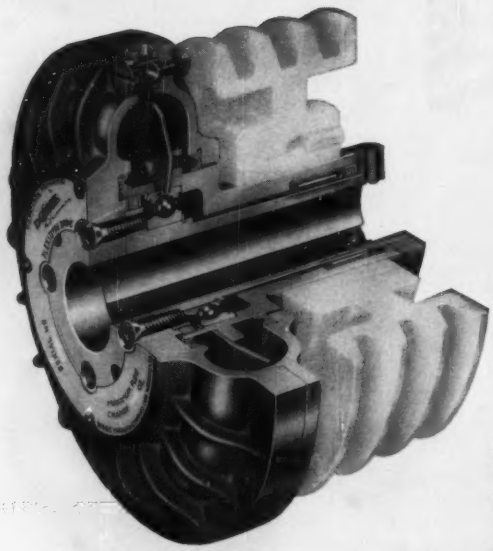

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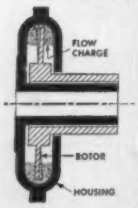
HOW FLEXIDYNE WORKS



The "dry fluid" in Flexidyne is tiny heat-treated steel shot. A measured amount, called the "flow charge," is contained in the housing, which is keyed to the motor shaft. Inside the housing is a rotor, free to revolve relative to the housing, but connected to the load.

When the motor is started, centrifugal force throws the flow charge to the perimeter of the housing, packing it between the housing and the rotor, which transmits power to the load. Initial slippage is momentary. Housing and rotor become locked together and achieve full load speed without slip and at 100% efficiency.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

DODGE

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Letters: Pro & Con

The Helitzers and the Forbaths flank World News Chief John Wilhelm.

Dear Readers:

This photo, taken at a recent luncheon meeting of McGraw-Hill editors here in our headquarters building, well illustrates those unexpected twists of events in which truth can prove stranger than fiction.

On Nov. 15, Pete and Margi Forbath left New York for Bonn, where Pete replaces Morrie Helitzer as chief of Mc-Graw-Hill's World News Bureau in the West German capital. Morrie recently returned to the U. S. to continue graduate study.

Pete, as many of you know, was our *Chementator* editor for the past year. He first joined *CE* in Feb. 1956. By the end of that year, he had so impressed us with his editorial talent that we assigned him full responsibility for our Process Flowsheets. When we went from monthly to biweekly frequency in 1958, thereby doubling the Flowsheet load, Pete took the increased load in stride, setting an exemplary pace in the development of worthwhile material for this *CE* feature.

Meanwhile, Margi Paul, a young, red-headed German girl, came to work on CE's art staff, forsaking a career as a fashion model. Her talents soon won her the assignment of designing layout and artwork for the Process Flowsheet. Her beauty, friendliness and soft Continental accent charmed everyone on our staff—including Flowsheet Editor Forbath. Pete and Margi's friendship began to extend past office hours.

Then fate stepped in to separate boy from girl. Pete was transferred to our Chicago office, and Margi resigned her job here and returned to Germany. But absence really did make the heart grow fonder in this case. Next thing we knew, Pete was asking for an extension of vacation time in August 1959 so that he could go to Germany and make Margi his bride.

The trip last month was different. Pete and Margi were traveling on McGraw-Hill expense, and Margi was proudly carrying a U. S. passport, having received her citizenship four days previously. We wish them Godspeed.

CECIL H. CHILTON
Editor in Chief
Chemical Engineering

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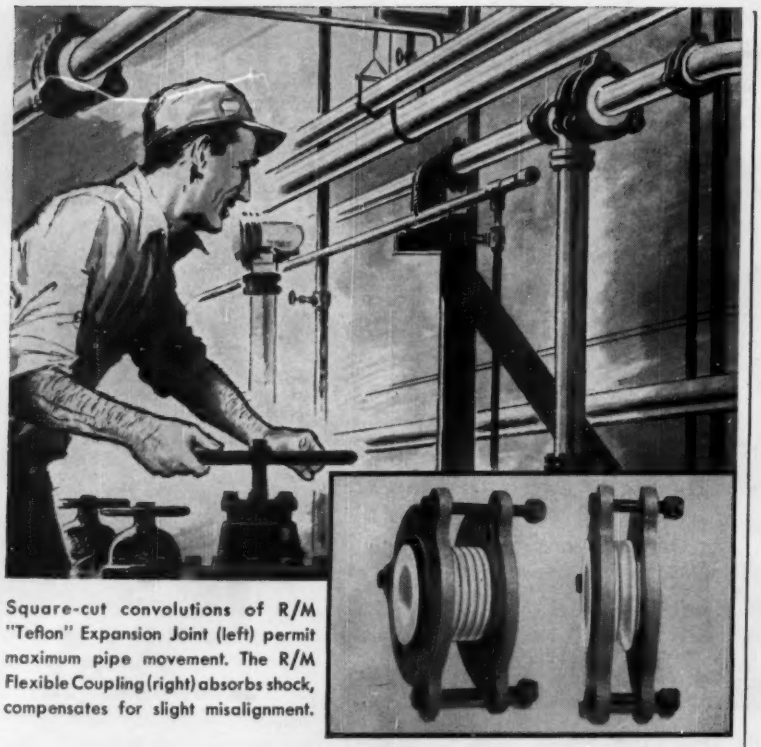

Square-cut convolutions of R/M "Teflon" Expansion Joint (left) permit maximum pipe movement. The R/M Flexible Coupling (right) absorbs shock, compensates for slight misalignment.

Best way to beat ✓expansion ✓vibration ✓misalignment of corrosion-resistant piping:

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Wherever you use glass, plastic or other corrosion-resistant piping, you need R/M "Teflon"* Expansion Joints and Flexible Couplings to take the brunt of surge, expansion and contraction, vibration and misalignment.

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*Du Pont TM for its TFE-fluorocarbon resins

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PRO & CON . . .

Murphy on Sylvester

Sir:

Dr. Sylvester's article on speechmaking (Aug. 8, pp. 143-144) was apparently written in rebuttal of my earlier article (Apr. 4, pp. 151-154). Dr. Sylvester says that I said things which I did not say. Either he did not read my article very well, or I did such a poor job in writing that it was impossible for anyone to know what I was saying.

He says, for example, that subject matter is the most important thing; that is, one must know one's engineering. And he implies that I said something different. But I didn't. I too said that subject matter is most important. My whole article was only to help the speaker communicate that subject matter to other people.

Communication between and among scientists is important—so much so that it seems superfluous even to mention it. It all goes much further than Dr. Sylvester's belief that one should merely please one's boss and other important people.

And whether one likes it or not, good writers and good speakers do communicate better than do poor ones—another absurdly obvious statement, I believe. The arts of writing and speaking do not come easily or automatically even to the smartest of people; there usually has to be training somewhere (think of all the hours we spent in spelling and English classes from the first grade on up). But Dr. Sylvester seems to believe that one need only start a car motor and the car will steer itself.

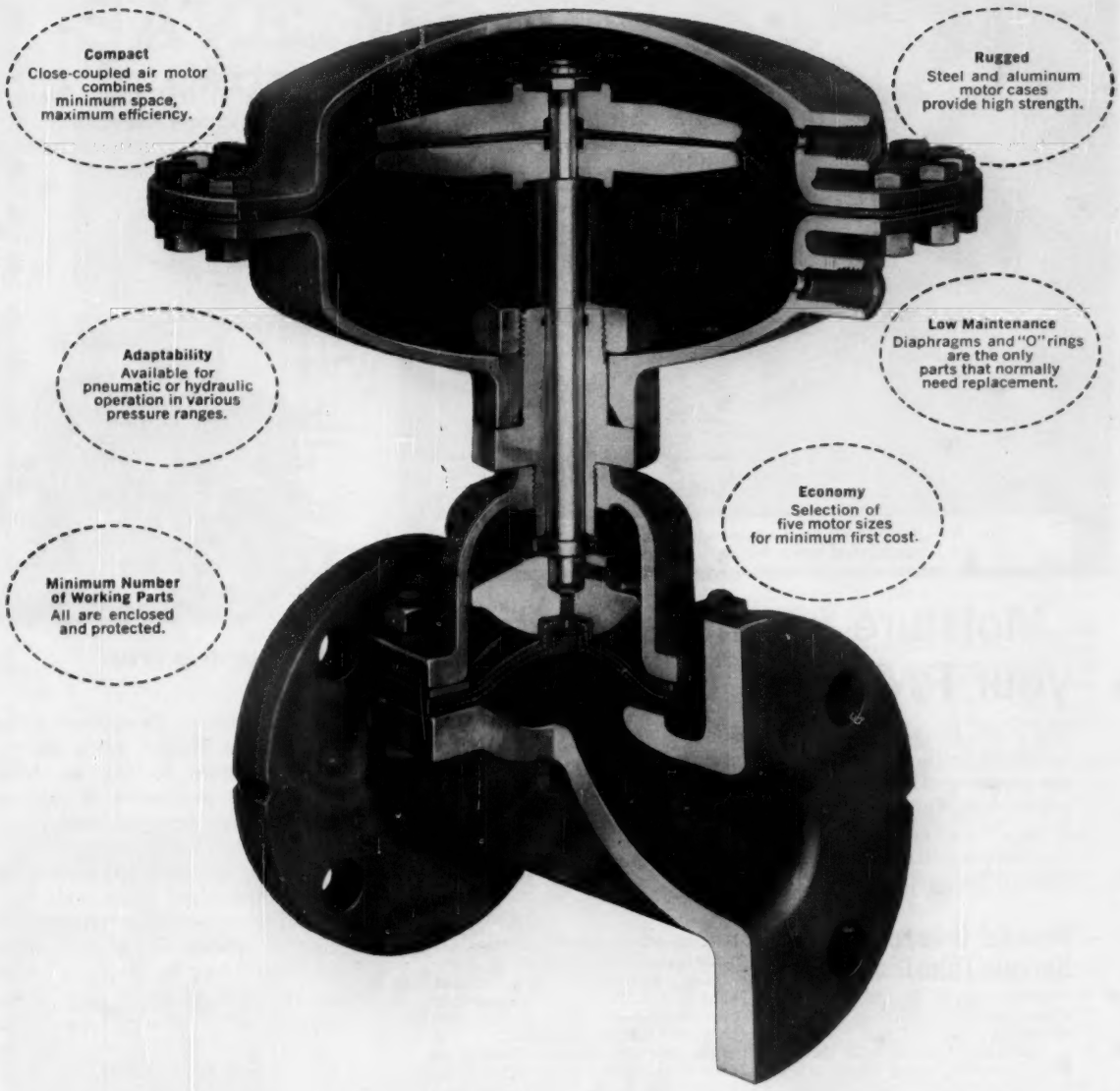
LAWRENCE MURPHY
New York, N. Y.

Bleach Process Patent

Sir:

Your writeup on the continuous bleaching system at British Columbia Forest Products (June 27, pp. 64-66) contained a reference to U. S. patent 2,889,119. The correct number is 2,889,199.

Although we reviewed your story before publication, no one detected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Moisture will never bother your RMC dial thermometer

The RMC hermetic sealing process makes absolutely certain that humid air will not be sealed in the instrument and locks all moisture out permanently. Each thermometer then goes through a series of severe tests. Only those with perfect sealing are accepted for delivery. When you order from RMC you get the *only* industrial thermometer that can *never* be affected by internal dial fogging or bimetal freeze-up.

"Bimetal Freeze-up" More Serious Than Dial Fogging

The first sign of moisture in a dial thermometer usually shows up as condensation inside the dial glass. You are probably familiar with this dial fogging problem which causes difficult reading and the eventual corrosion of the bimetallic element. You may not, however, be familiar with another and actually more serious moisture problem—bimetal "freeze-up."

If moisture is sealed in, or enters a thermometer dial it will find its way to the bimetal element. Then at extreme low temperatures this moisture freezes on the element and bearing surfaces, and the bimetal element will not function should the temperature go lower. Therefore, the operator of the equipment would never know that the temperature had gone below the last indication when the element became frozen.

Here's what makes such a condition hard to spot. The thermometer would operate properly again after a temperature rise of perhaps 20°, and would continue accurate indication even though the fluid dropped again to an even lower temperature than before. However, after it remained at the new low for a few hours, it would again freeze up. Then, as before, any further drop in temperature would not be indicated.

Only a dry-air hermetic seal, as used by RMC, can prevent both dial fogging and bimetal freeze-up. RMC even goes a step further by providing for recalibration at any time without breaking the air-tight seal. An external dial reset screw—exclusive with RMC—permits recalibration without opening the instrument in any way.

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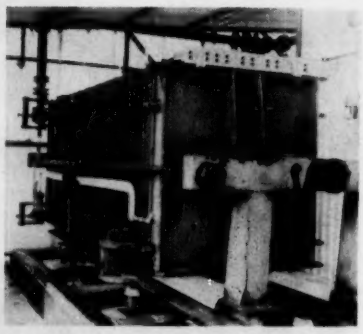
the error at that time. We are sorry it was overlooked.

THERESE DAVIS
Hooker Chemical Corp.
Niagara Falls, N. Y.



HCl Electrolysis Costs

Sir:

Your article, "Electrolysis Saves Chlorine in Waste" (July 25, pp. 63-66), refers to the de Nora process for production of chlorine and hydrogen from byproduct HCl. While I found this article very interesting, I cannot reconcile some of the data given in the table.

Under "operating characteristics" you give a production capacity of 3,900 lb. of chlorine and 18,300 cu. ft. of hydrogen per day. In the section on "operating costs," the figures seem to indicate a production rate of 20 tons/day.

Would you please clarify these figures?

H. YARROW
F. W. Berk & Co.
London, England

► *The operating characteristics listed in our story refer to a single 40-frame electrolyzer (shown in photo). The estimated operating cost are based on an assumed 20-ton/day plant, using a multiplicity of such production units.*—ED.

Your comments and opinions are important. Send them to Editor, Chemical Engineering, 330 West 42nd St., New York 36, N. Y. They'll be welcomed.

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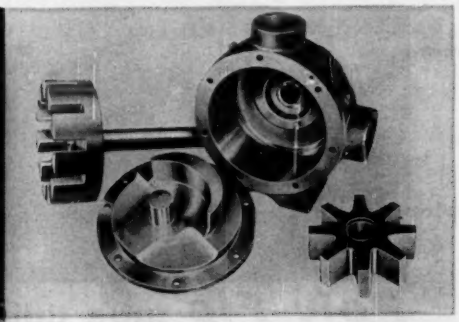

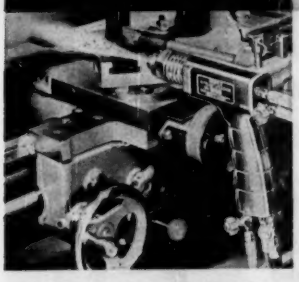

The Colmonoy Spraywelder is used to hard surface lathe-mounted pump parts. After application, alloy is torch fused creating a welded bond between overlay and base metal. Alloy in rod form is used to overlay irregular surfaces.

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Gear pumps—all pumps—used in the chemical and processing industries last longer with Colmonoy Hard Surfacing Alloys protecting vital parts. Processors plagued by maintenance problems—pump manufacturers too—have found it makes good sense to use Colmonoy Alloys to solve their tough corrosive/abrasive problems. Structural metals used in pumps don't provide the double protection—against harsh corrosion and abrasion—that Colmonoy Alloys provide so well.

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Granular and powdered resins. Slow speed mixers are often unable to keep up production because of the formation of "balls" which are miserable to disperse. They are the culprits that require time under slow agitation or result in "fish eyes" which can only be cleaned up by a filtering operation. It costs money to throw away the unused filtered resin materials. The high-speed, patented Cowles impeller hits hard and eliminates these ball formations. Thus the "COWLES DISSOLVER" saves time, eliminates filtering waste, and saves money.

Soft, gummy resins. This type also tends to "ball" through the formation of a soft outer layer surrounding a core of unwetted resin. Here again the patented Cowles impeller operating at high speed rapidly attacks the balled material. As the outer layer becomes soft it is rapidly scoured off in the impeller's intense energy discharge zone. Complete dispersion is rapidly achieved.

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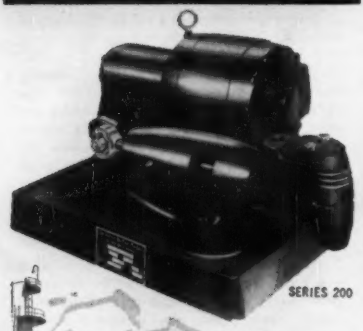

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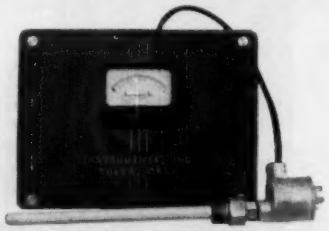

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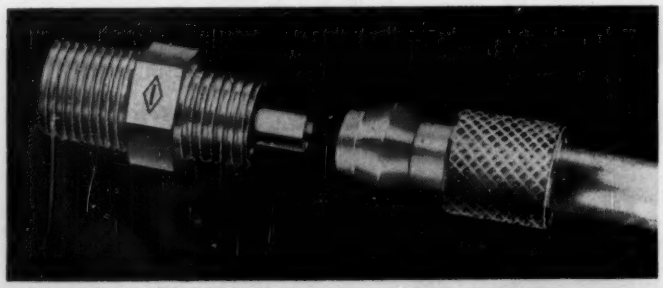

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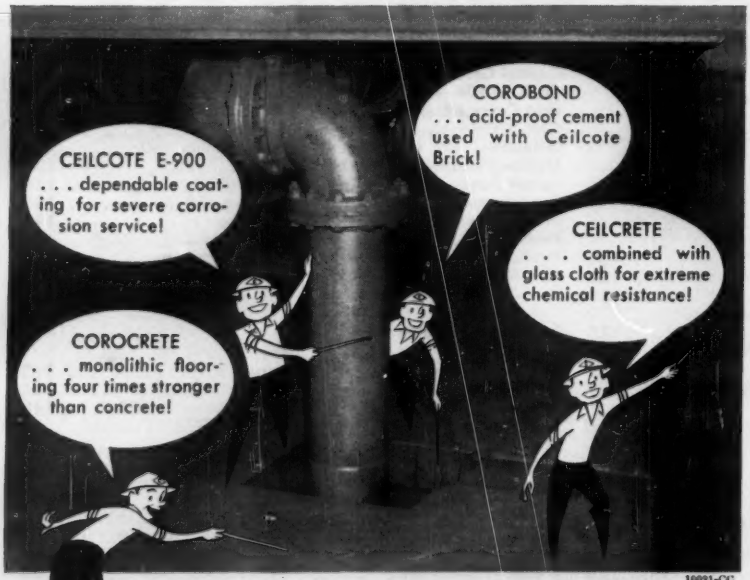
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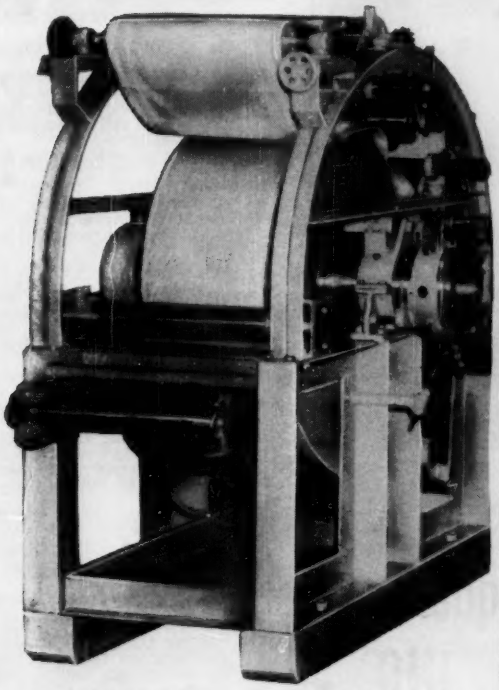

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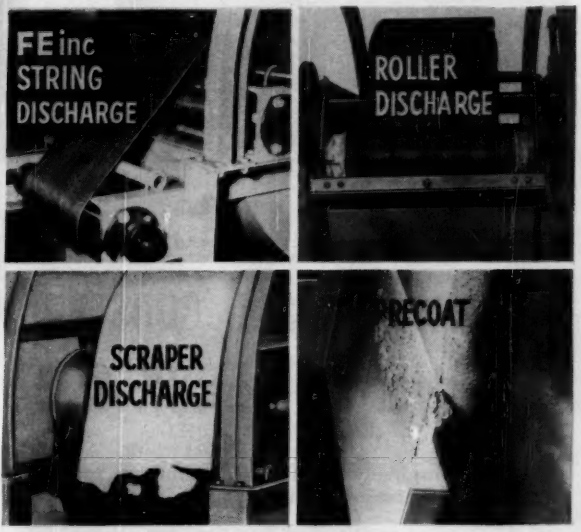

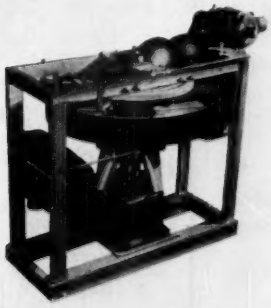

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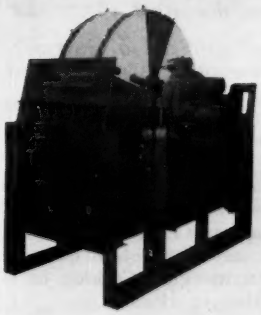

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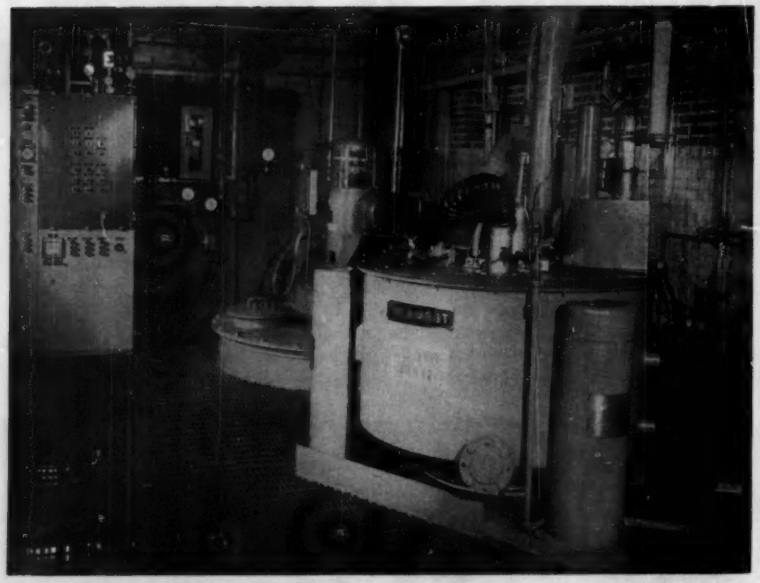

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216 *Gen. American Transp. Corp.

* From advertisement, this issue.

Coatings.....Syl-off coatings have natural nonoily lubricity & water repellency.....won't migrate, contaminate or transfer. Descriptive brochure offered.
63 *Dow Corning Corp.

Continuous Mixer.....The new Shear-Flow can be powered with motors ranging from 1 to 10 hp. depending on the power required by the application. Bul. No. RL-200.
R261 *Gabb Special Products Inc.

Corrosion-Proof Products.....such as corrosion-proof cements, corrosion-proof tank linings, and rigid plastic structures are described in Bulletin CC-3.
R257 *Atlas Mineral Products Co.

Fabricating.....Custom plate work of all kinds and sizes. Complete inspection facilities. The booklet on plate fabricating facilities and services is available.
110-111 *U. S. Steel, American Bridge Div.

Floors.....Engineered Floors to withstand impact, thermal shock, abrasion and expansion without cracking or spalling. A complete flooring package available.
246 *The Ceilcote Co., Inc.

High Alloy Castings.....New General Catalog No. G-159 contains tables to help you select the proper alloy for your casting specs & other useful information.
262 *The Duraloy Co.

Insulation.....The new Industrial Insulation Catalog is offered. Also Data Sheets on the complete line of accessories for use with Foamglas insulation.
119 *Pittsburgh Corning Corp.

Insulation, Pipe.....is available in full range of standard pipe sizes & in block form. Single thickness to five inches. Specials to 44" O.D. Bul. No. 65610.
59 *Union Asbestos & Rubber Co.

Lead Products.....These products include chemical lead sheets to your requirements; pipe, bends, traps & standard fittings. Bul. 162, the Lead Handbook for the CPI.
225 *American Smelting & Refining

* From advertisement, this issue.

Want to build up your files and keep them up-to-date? You can get any publication in this comprehensive guide —free—just for the asking.

It's easy—simply circle item's number on the Reader Service Postcard and mail. Replies will come directly from companies offering the literature.

NIAGARA VERTICAL FILTER AT KIND AND KNOX GELATIN COMPANY, CAMDEN, N. J.

"In half the time needed by our old filter press, we can run a batch of gelatin in the thin liquor stage through our new NIAGARA VERTICAL FILTER," says Edward Bohn Jr., assistant plant superintendent for one of the largest U. S. gelatin producers.

Remarkable reductions in down time and labor costs also are reported by Kind and Knox with its new NIAGARA FILTER. "Resetting the NIAGARA for a new run takes one-fourth the time and one man can handle the procedure without a helper," Bohn says. "Our regular filter press requires two men working two hours to change 50 filter cloths. With NIAGARA, hot water under pressure completely removes the residue in minutes, and the unit does not have to be opened. Also, there are no filter cloths to clean or replace in our NIAGARA FILTER."

The plant operates 24 hours a day, 7 days a week, and to date there has been no operational trouble with the NIAGARA FILTER. This compact filter has a base measurement of only 52" x 102", so there is a big savings in floor space.

For details on how custom engineered NIAGARA FILTERS can help with your processing problems, write for bulletin NC-457, or see the NIAGARA section in Chemical Engineering Catalog.

Niagara® FILTERS

A DIVISION OF

American Machine and Metals, Inc.

DEPT CEN—1260

EAST MOLINE, ILLINOIS

Divisions of American Machine and Metals, Inc.

TROY LAUNDRY MACHINERY • RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS • NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC COMPANY • HUNTER SPRING COMPANY • GLASER-STEERS CORPORATION

SOCK that wrench without dangerous arm swing

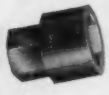
Snap-on® CUPPED-ANVIL BOXOCKETS®

These big, tough, cupped-anvil wrenches make teardown and reassembly faster, safer, easier. They've proved invaluable at refineries, processing plants, power plants — any place where large bolts and nuts are turned by sledging.

The wrench is turned by means of an air-powered impact tool with a bull nose adaptor which is inserted into the wrench's cupped-anvil head. No more sledge swing on high catwalks or scaffolds. With this wrench, a man can hold still and let the air tool do the work. Wrench can also be driven with a sledge hammer, if desired. Twenty-seven wrench openings from 1-7/16" to 4-5/8"; over-all wrench lengths from 7-5/8" to 20".

SNAP-ON SLEDGE BOXOCKETS

SNAP-ON also makes a full range of regular sledge wrenches. Twenty-seven wrench openings from 1-1/2" to 4-5/8" with over-all wrench lengths from 7-5/8" to 19-31/32". Sockets are available for both the cupped-anvil and regular sledge BOXOCKETS. The sockets have hex driver heads which are inserted into the BOXOCKET openings. Thirteen wrench sizes — 1-5/8" to 4-5/8".



Put new safety into your big nut- and bolt-turning jobs. Order cupped-anvil wrenches from your SNAP-ON representative now. Branch offices and warehouses in industrial centers throughout the country. Write us for industrial calalog.

FOR ALL INDUSTRY

SNAP-ON TOOLS

8106-L 28th AVENUE • KENOSHA, WISCONSIN

LITERATURE . . .

Material of Construction.....Booklet B-111B "Properties of Kennametal" and the new booklet B-666, "Proven Uses of Kennametal and Kentanium" are available on request.
264 *Kennametal Inc.

Protective Coatings.....for steel tank linings, concrete floors, tank cars, etc. Selection of coatings & other Plasite Products covered in booklet.
L261 Wisconsin Protective Coating Co.

Protective Coatings....Polyken is made of an inert polyethylene, with an unplasticized, non-drying film. Goes on quickly, right from the roll. Additional information.
52 *The Kendall Co.

Refractories.....The line of refractories has been enlarged by the addition of new heavy duty firebrick & new ramming mixes. Complete properties sheets & information.
125 *The Babcock & Wilcox Co.

Stainless Steels.....Standard stainless grades as well as many special stainless steel that are designed to help solve chemical processing problems. Tech. bulletins & manuals.
48 *Armco Steel Corp.

Wire Cloth.....For corrosive service, cloth with accurate mesh count, close tolerance wire diameter, precision weaving, etc. Bulletin F-C has details.
252 *Newark Wire Cloth Co.

Wire Cloth Fabrications.....Wire cloth manufactured from any metal or alloy, including titanium, in nine basic weaves. The 94-Page Catalog is offered.
46 *The Cambridge Wire Cloth Co.

Electrical & Mechanical

Dry Fluid Drives.....Flexidyne is available, off the shelf, in Drives & Couplings. Capacities range from fractional to 1,000 hp. Technical bulletin.
236 *Dodge Mfg. Corp.

Gas Turbines....as a dependable power source for generators & compressors, as a propulsion unit for high-speed boats & in other applications. Information about all types.
60 *Solar Aircraft Co.

Mechanical Seal.....Dura Seal meets a wide range of pressures, temperatures and liquids. Information on types of Dura Seals to meet your sealing needs in Catalog 480.
266 *Durametallic Corp.

Mechanical Seals.....Type U seal for service at temperatures of from 100 below zero to + 650 F, and for pressures from 0 to 100 psi. Engineering information offered.
218 *Borg-Warner

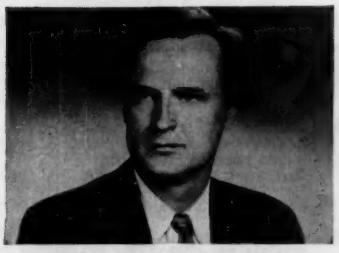
Motor Mount.....With the new Equi-Poised Motor Mount the motor can be mounted in almost any position around perimeter of reducer. Dimensions, etc. in Bul. 7100.
105 *The Falk Corp.

Oiltight Control Stations.....A wide selection of control units to satisfy every operating requirement. Rugged construction & generous wiring room. Publication 6090.
123 *Allen-Bradley Co.

* From advertisement, this issue.

News from
National Carbon Company
Division of Union Carbide Corporation • 270 Park Avenue, New York 17, New York
In Canada: Union Carbide Canada Limited, Toronto

National Carbon Design Engineers expand your engineering force



J. L. MILLER
Design Engineer

Mr. Miller graduated from Yale University with a B.S. in Chemical Engineering and joined National Carbon Company in 1948.

Since then, Mr. Miller has worked on applications of carbon, graphite and "Karbate" impervious graphite materials in corrosive services both in the field and in the laboratory. He has been particularly active in application engineering and development of graphite anodes for impressed current cathodic protection.

SAVINGS ON MAINTENANCE COSTS

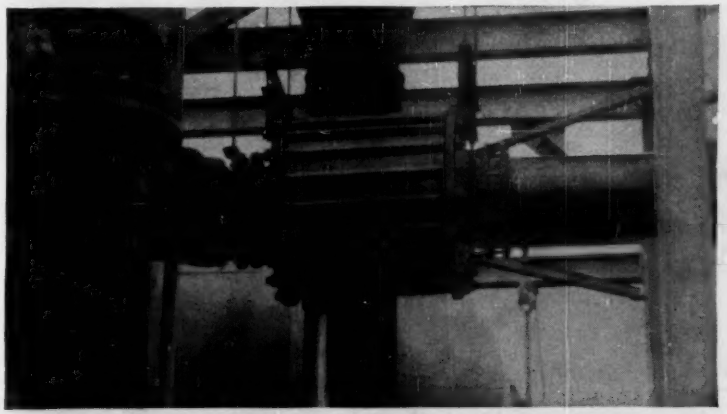
Two typical reports show trouble-free service with "Karbate" impervious graphite pumps in chemically cleaning equipment.

A petroleum company using a Type F centrifugal pump on its portable equipment cleaning rig reports, "We are very pleased with the performance of this equipment and would not hesitate to recommend its use to others for cleaning operations."

A chemical equipment cleaning company uses Type F centrifugal pumps for transferring muriatic acid from tank cars to storage tanks and from these tanks to trucks. "Karbate" impervious graphite pumps were installed here after attempts to move the acid by other methods were unsatisfactory. Maintenance on other corrosion-resistance lined pumps proved too costly. Twelve "Karbate" impervious graphite pumps, one to each station, are handling this operation with virtually no maintenance.

"KARBATE" EQUIPMENT USERS REALIZE MANY SAVINGS!

Users of "Karbate" Impervious Graphite Equipment Report Savings in Recovered Product . . . on Long Equipment Life . . . and on Maintenance Free Operations.

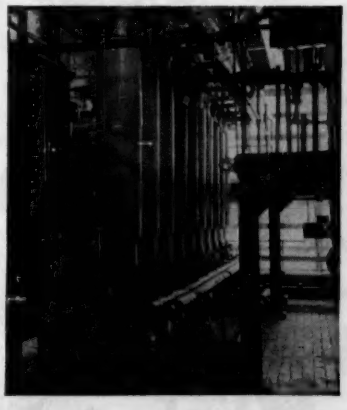


A 20" "Karbate" Impervious Graphite Entrainment Separator in an Acid Vapor Line.

SAVINGS IN RECOVERED PRODUCT

After installing a 20" "Karbate" impervious graphite Type MV entrainment separator on a spin bath evaporator, a major rayon producer recovered chemicals valued at approximately $2800 a year. These savings paid the equipment cost in roughly a year.

Based on the proved efficiency and savings in this installation, this company has purchased eleven additional units for use throughout its operations.



SAVINGS ON LONG EQUIPMENT LIFE

In 1951, a large pharmaceutical producer installed 10 "Karbate" Series 240A shell and tube heat exchangers to cool an organic slurry containing HCl. These exchangers have been in service for nine years, and are operating today with minimum maintenance.

Each exchanger has twenty-four 7½′ long tubes, ⅞" I.D. x 1¼" O.D. and operates as a single pass unit.

10 "Karbate" Series 240A Heat Exchangers cool an organic slurry containing HCl.

"National", "Union Carbide", "N" and Shield Device and "Karbate" are registered trade-marks for products of
NATIONAL CARBON COMPANY
UNION CARBIDE

WIRE CLOTH

for

FILTERING

SIZING

STRAINING

TESTING

In all metals, in all weaves ...woven to the highest accuracy standard in the industry. You just can't buy a better wire cloth than "NEWARK." Hundreds of meshes, weaves and metals to fit *your* specific need. Years of processing experience to help you pick the right wire cloth for *your* application. Write for Bulletin FC or write us about your problem. Fast deliveries, best cloth, lowest cost when you call on NEWARK.

NEWARK for ACCURACY

Newark Wire Cloth COMPANY

351 VERONA AVENUE • NEWARK 4, N. J.

LITERATURE . . .

Rupture Discs.....are available in sizes ranging from ⅛" to 44" in diameter, covering rupture pressures from 3 to 100,000 PSI. Information on request.
217 *Black, Sivalls & Bryson, Inc.

Safety Switch.....Visible blade construction in these switches insures safety. The latest Safety Switch Bulletin is now available on your request.
127 *Square D Company

Solid Wheel Turbines.....Standard turbines are made in capacities up to 2,500 hp, with either cast-iron or cast-steel casings. The standard wheel is carbon steel. Bul. S-116.
58 *The Terry Steam Turbine Co.

Speed Control.....Ampli-Speed has nearly stepless speed change & gives speed regulation within ± 2%. Illustrated publication No. 243 tells how it works.
227 *Electric Machinery Mfg. Co.

Speed Variators.....Available in 18 models ranging from fractional to 16 hp at 1750 input RPM. Bul. K-200 contains detailed description, photographs, specifications, etc.
167 *Cleveland Worm & Gear Div.

Syncrogear.....Shaftmount Syncrogears reduce speeds. Available for ¼ to 40 h.p., output speeds 125 to 5 rpm. Color illustrated Brochure No. F-2003 offered.
201 *U. S. Electrical Motors Inc.

Thermocouples.....MegopaK thermocouples manufacturing area is clean, dry, air-conditioned. Information, including Catalog and Price List G100-4 now available.
70 *Minneapolis Honeywell.

Turbines.....with a totally enclosed governor . . . totally enclosed, independently operated safety trip . . . easily replaceable packing & bearings, etc. Cat. 200.
81 *Coppus Engineering Corp.

Handling & Packaging

Bulk Trucks.....Complete information on how Sprout-Waldron pneumatic bulk trucks may fit your application is contained in Bulletin 205. Available on request.
222 *Sprout-Waldron & Co.

Conveyors, Oscillating.....Flexmount for light-duty, Coilmount for medium-duty, and Torqmount for heavy-duty service. New Book 2744 contains complete data.
83 *Link-Belt Co.

Material-Level Indicators.....is a high-level/low-level indicator that provides automatic control when a desired maximum or minimum level of material is reached. Bul.
109 *Fuller Co.

Payloader.....features two speeds forward and reverse; power-steer; power-transfer differential; 4500 lbs. breakout force; etc. Data on this unit & its attachments.
67 *The Frank G. Hough Co.

Pneumatic Conveying System.....Literature describing pneumatic conveying pumps, air activated containers, air-float air-gravity conveyors, is available on request.
36 *Kennedy Van Saun

* From advertisement, this issue.

LITERATURE . . .

Scales..... Printweigh are available in a wide range of models including Portable, Floor & Bench types, Built-in Hopper, Overhead Track & Motor Truck types. Bul. 2017.
208 *Toledo Scale Corp.

Heating & Cooling

Air Preheater.....Facts about the low-cost maintenance, easy inspection, in service cleanability, space saving compactness of the Air Preheater in a new brochure.
219 *The Air Preheater Corp.

Coolers.....Catalog "A" contains complete information on Rotary Water Tube, or Contact Type, Cooler as well as Rotary Air Coolers and Rotary Indirect Air Coolers.
BL259 *Davenport Mach. & Fdry.

Cryogenic Vessels.....A full line of vessels includes a design to meet most requirements for low temperature storage. Further details available on request.
77 *Chicago Bridge & Iron Co.

Gas Meter.....This new rotary gas meter is accurate to 3000 cfh and up to 125 psi. Only 14" long—mounts in the line. Requires no special supports. Complete data.
99 *Roots-Connersville Blower Div.

Heaters.....Catalog 956 covers Grid Unit Heaters, Blast Heaters and Radiators. Designed for operation on steam pressure up to 250 PSI 450 degree temperature.
256 *D. J. Murray Mfg. Co.

Heat Exchanger....Multi-fintube units permit true heat exchanger standardization. Valving permits any unit to be serviced while others operate. Bulletin 111.
179 *Brown Fintube Co.

Heat Exchangers, Liquid/Gas.....Units can be supplied in any alloy, any size, for any application. Additional information available on request.
128 *Marlo Coil Co.

Heat Exchangers, Plate.....range in size from laboratory models to capacities of over 200,000 lbs./hr. Further information available on request.
28-29 *The De Laval Separator Co.

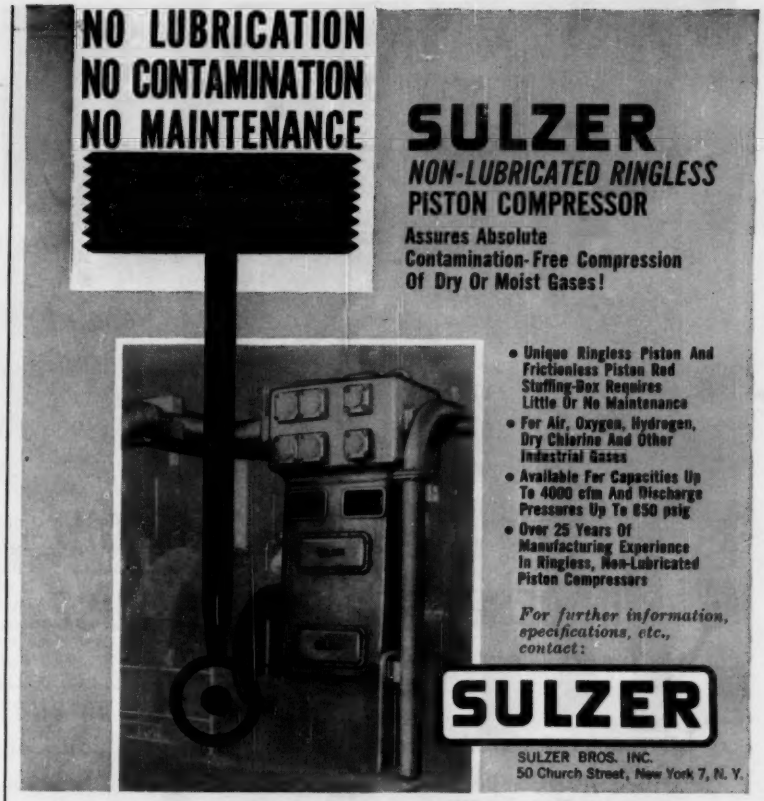
Liquid Phase Heater.....The Vapor Modulatic Hi-R-Temp phase heater is a forced circulation, coiled tube, direct-fired heater of two-pass design. Bul. No. 4023.
207 *Vapor Heating Corp.

Package Refrigeration Units.....Both packaged cooling units & packaged compressor units for use with remote heat exchangers are available. Bulletins (820,427) offered.
274 *The Vilter Mfg. Co.

Panelcoil..... Complete technical data and pricing on Panelcoil can be found in Data Sheet 15-60 Series and in Price Bulletin 259 which is available on request.
TL259 *Dean Products, Inc.

Refrigeration Equipment.....handles loads between minus 150 & plus 100 degrees F., using any refrigerant required & using fully automatic controls if desired. Booklet.
200 *Frick Co.

* From advertisement, this issue.


NO LUBRICATION
NO CONTAMINATION
NO MAINTENANCE
SULZER
NON-LUBRICATED RINGLESS
PISTON COMPRESSOR
Assures Absolute
Contamination-Free Compression
Of Dry Or Moist Gases!
• Unique Ringless Piston And Frictionless Piston Rod Stuffing-Box Requires Little Or No Maintenance
• For Air, Oxygen, Hydrogen, Dry Chlorine And Other Industrial Gases
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• Over 25 Years Of Manufacturing Experience In Ringless, Non-Lubricated Piston Compressors
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50 Church Street, New York 7, N. Y.

There's a MARSH thermometer for every need
the
dial thermometer
at its best
In the Marsh Dial Thermometer you have the best type—the bourdon tube type—in its highest development. These are instruments made in the Marsh manner—instruments that embody the recognized precision and accuracy of Marsh Pressure Gauges.
Both vapor-tension and gas-filled types are available in the broad Marsh line...a type, size, case-style, finish and temperature range to solve practically any dial thermometer problem.
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RIGID STEM
Ask for the Thermometer Catalog
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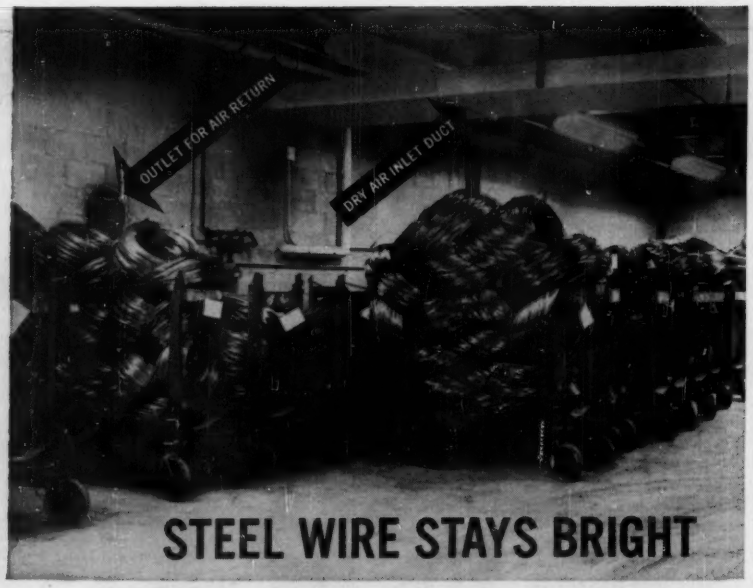
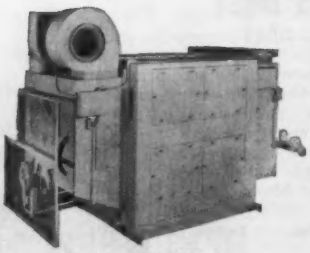
Houston Branch Plant, 1121 Rothwell St.
Sect. 15, Houston, Texas



STEEL WIRE STAYS BRIGHT IN DESERT-DRY WAREHOUSE

A LECTRODRYER maintains an average relative humidity of 16% the year around in Keystone Steel & Wire Company's storeroom at Peoria, Ill. As a result, bright steel wire exposed there to the atmosphere for a month was in excellent condition when received by the customer. Prior to dehumidification of the storage area, wire would begin to tarnish in a day or so.

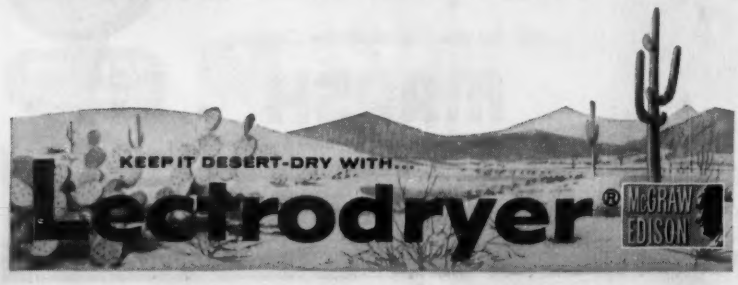
A DRY warehouse may solve your storage problems



New Type CH Lectrodryer

Hundreds of companies use Lectrodryers in a similar manner to dehumidify storage and work areas, thereby safeguarding products during warehousing, processing or packaging.

FOR CASE HISTORIES on these and for any other drying problem answers, write Pittsburgh Lectrodryer Division, McGraw-Edison Company, 303 32nd Street, Pittsburgh 30, Pennsylvania.



LITERATURE . . .

Rotary Kilns.....feature full-floating type roller ring and roller supports which insure easy alignment, & continuous operation. Bulletin No. 1115.
32 *Traylor Engineering & Mfg.

Steam Traps.....Information on trap capacity ratings, plus data on how to correctly size, install & maintain for any pressure, temp., or load presented in 48-pg. Book.
108d *Armstrong Machine Works

Steam Traps.....Thermostatic steam traps operate on a true balanced vapor-pressure principle, they discharge air, condensates & other non-condensables. Cat. 400.
R265 *W. H. Nicholson & Co.

Instruments & Controls

Computer.....Descriptive literature on the G-15 digital computer covers the many valuable features and its use in the chemical process industries.
185 *Bendix Corp.

Computer.....Recomp offers many outstanding features such as exclusive built-in floating point arithmetic. Also offers high-speed input and output. Information.
214 *Autonetics Div. of N. American

Computers.....Company provides computing and information processing systems for business, industry, science, engineering, education and defense. Information.
12-13 *General Electric

Control.....FultroMatic is a 3-in-1 controller, positioner and valve. Gives positive control for process temperatures or pressures. Data in Bulletin XC-755.
*Robertshaw-Fulton Controls Co.
229

Controller....Dynalog Controllers have no slidewires, no galvanometers, & no balancing motors. Nothing to wear out or get out of alignment. Details in Bul. 20-10.
173 *The Foxboro Co.

Controls.....The Massometer is calibrated with any maximum output between 40 & 200 lbs. per minute. Maximum volumetric capacity is 6 cubic ft. per minute. Details.
197 *Wallace & Tiernan Inc.

Dial Thermometer.....Both vapor tension and gas-filled types are available in either distant reading or rigid stem types. Catalog offered on request.
BR253 *Marsh Instrument Co.

Gauges.....Liquidometer Gauges measure virtually all liquids conveniently, continuously, and correctly. A type for practically every application. Details.
234 *The Liquidometer Corp.

Instrument.....Electr-O-Level is used now on polyethylene levels aluminum ore levels pulverized refractory levels; liquid oxygen; etc. Bulletin L-1053.
TR242 *Instruments, Inc.

Instrument.....Model 77 Continuous Turbidimeter-Colorimeter for measuring color in continuous streams. Consists of an Analyzer Unit & Control Unit. #14-51-13.
R255 *Beckman Instruments, Inc.

* From advertisement, this issue.

SPLIT-EYELET CONNECTORS

For faster, easier connection of spray nozzles, branch lines and equipment to piping and tubing carrying liquids, gases or air up to 250 psi. Write for Bulletin 93.

FOR BETTER PERFORMANCE

SPRAY NOZZLE ACCESSORIES

ADJUSTABLE JOINTS

For easy, exact adjustment of spray direction. Made in size for ¼" to 2½" pipe in brass, steel and stainless steel. Write for Bulletin 97.

...EASIER INSTALLATION

FOR COMPLETE SPRAY NOZZLE INFORMATION WRITE FOR CATALOG 24

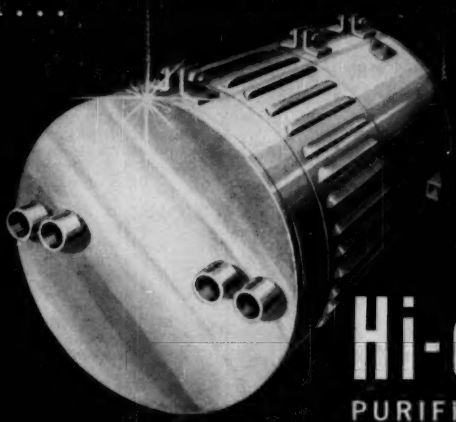
LINE STRAINERS

Special non-collapsing screen design for pressures up to 125 psi, for all pipe lines from ¼" to 6" size. Also high pressure strainers for up to 5,000 psi service. Write for Bulletin 94.

SPRAYING SYSTEMS CO.

3275 RANDOLPH STREET • BELLWOOD, ILL.

steam process headaches are quickly relieved with . . .

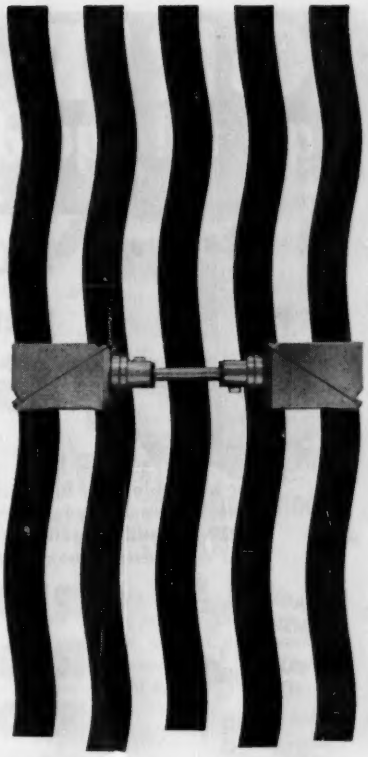


Hi-eF PURIFIERS

Remove damaging particles, line scale, condensate, oil from steam processes. Prevent slugs and riser discharge in evaporator and boiler service. Hi-eF separation guaranteed better than 99% efficient. No moving parts, filters or screens result in low-cost, maintenance-free performance. SPECIFICATION MANUAL 803 contains data on 13 types of purifiers, separators, mist extractors, scrubbers. Write.

THE V. D. ANDERSON CO. 1977 West 96th Street, Cleveland 2, Ohio

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION



for measuring color in continuous streams

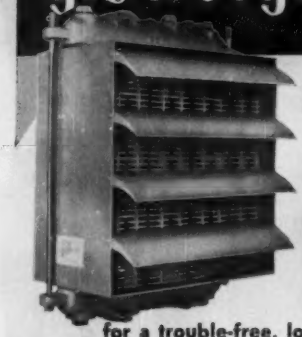
Beckman Model 77 Continuous Turbidimeter-Colorimeter takes the guesswork out of clarity and color determinations... gives rapid, accurate readings to better than ±2% of light transmission. The Model 77 consists of an Analyzer Unit and Control Unit... precision designed and ruggedly constructed to bring colorimetry to continuous process applications. Among the wide range of applications are control of water and industrial waste treatment processes, and colorimetric quality control analyses in the production of chemicals and petroleum. ⊠ Outstanding Beckman features are: ±1% repeatability... push-button scale expansion from 0-100% to 0-50% transmittance... wavelength ranges from 350 to 1000 mμ. ⊠ Complete information applicable to your specific process is available from your nearest Beckman Sales Office. Or write direct for Data File 14-51-13.

Beckman
Scientific and Process Instruments Division
Beckman Instruments, Inc.
2500 Fullerton Road,
Fullerton, California

INSTRUMENTS IN YOUR FUTURE 25 YEARS 1935-1960

GRID's got to be good!

The best guarantee any product can have is its users.



LOOK at the plants that depend upon GRID

UNIT HEATERS
BLAST HEATERS
RADIATORS

for a trouble-free, low maintenance cost heating system - One that will serve without service - Installations made in 1929 are still operating without need for repairs. GRID'S design and construction makes the difference!

ABBOTT LABORATORIES — **GRID** — Cast Iron Construction resists corrosion externally from acid fumes and internally from electrolysis. No leaking from rotted cores.

BUCKEYE COTTON OIL CO. — **GRID** — one-piece cast iron heating sections and headers are leak-proof on steam pressure up to 250 p.s.i. 450° temperature. Smaller steam lines cost less.

DIAMOND ALKALI CO. — **GRID** — heating sections with widely spaced fins cast integral with steam chambers are easy to clean - Will not "mat" on air intake side.

ANSUL CHEMICAL CO. — **GRID** — design develops low outlet temperatures and, with proper fan volumes, delivers warm, comfortable air to floor - No wasted heat at ceiling.

GIVAUDAN-DELAWANNA CORP.

Get complete information on a GRID System for your plant. Write for catalog #956 GRID CAST IRON STEAM HEAT TRANSFER SURFACE.

Representatives in principal cities

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D. J. MURRAY MANUFACTURING CO.

WAUSAU — *Manufacturers Since 1883* — WISCONSIN

LITERATURE . . .

Liquid Meter.....The new, stainless steel Auto-Stop liquid meter in size 1½", capacity 20 to 100 gpm is described in detail in Bulletin 94/10. Send for your copy.
258 *Neptune Meter Co.

Mass Flowmeter.....with 12 standard ranges feature low pressure drop, & accuracy independent of variations in density, pressure, viscosity & temperature. Bul. GEA-6925A.
212 *General Electric Co.

Permanent Recorder.....Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart and is designed for permanent installation.
114b *Bailey Meter Co.

Portable Indicator.....The self-contained, lightweight, Heat Prover analyzer enables quick, easy check on combustion conditions. Features dual range dials.
114a *Bailey Meter Co.

Thermometers, Dial.....are thoroughly dampened with silicone on the bimetal elements & a special precision-machined bearing on the shaft. General Catalog.
240 *Rochester Mfg. Co., Inc.

Transmitter.....New dp transmitter tames pulsating flow with adjustable internal damping. Achieved by a needle valve which restricts the flow of sealing oil. Cat. 10B1465.
181 *Fischer & Porter Co.

Transmitter.....The new Transcope is a high-accuracy, motion-balance transmitter for Gage Pressure, Volumetric Pressure, Volumetric Load, Temperature. Bul. 98385.
112 *Taylor Instrument Co.

Pipe, Fittings, Valves

Fittings & Flanges.....Welding fittings & flanges are available in carbon steel & the B&W Croloys in a complete range of types & sizes. Bulletin FB502 offered.
126 *The Babcock & Wilcox Co.

Pinch Valve Systems.....with 3" to 14" I.D. sizes, with 50, 100, and 150 psi line pressure ratings. Temperatures to 200 F. New Catalog No. 609 is offered.
R259 *Mine & Smelter Supply Co.

Pipe.....Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200 F. Information.
220 *Saran Lined Pipe Co.

Pipe Connections.....are manufactured in standard stock sizes from 1" to 30", but special sizes can be manufactured on request. New Grayloc catalog offered.
R275 *Gray Tool Company

Pipe Fittings.....Speedlines controlled wall thickness can make a difference in your critical process lines. Complete catalog information available on request.
107 *Horace T. Potts Co.

Pipe, PVC.....available in sizes from ½ inch to 12 inches in diameter & schedules A, 40, 80, 80, & 120. Easy to fabricate & join, has excellent impact resistance. Bul. 24.
101 *U. S. Steel, National Tube Div.

* From advertisement, this issue.

ONE PUMP FILLS TIN CANS OR TANKERS

Vari-Flo changes capacity instantly

Do you have pumping jobs that vary from a "dribble" to a "gusher"? Then you should learn about Blackmer Vari-Flo . . . the new variable-capacity pump that might do the job several pumps are doing for you now. The Vari-Flo is much like other Blackmer vane-type rotary pumps with the important addition of a dial-operated "flow changer". Works with an ordinary standard motor, too . . . no costly variable-speed drive needed. Whether you're filling a tin can or a tanker, you can dial the proper flow rate as easily as phoning your Blackmer distributor. Give him a call or write for Bulletin 600 if you see a chance for an application.

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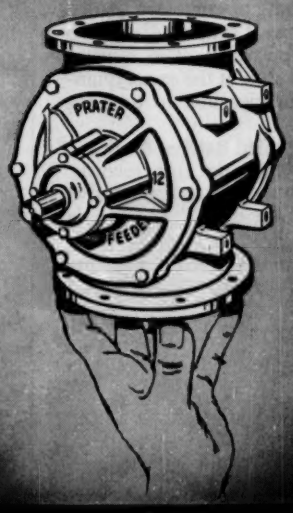
ROTARY AIRLOCK FEEDERS

for DUST CONTROL and PNEUMATIC CONVEYING



WRITE FOR BULLETIN P58

PRATER PULVERIZER COMPANY

1517 South 55th Court • Chicago 50, Illinois

Atlas

PLANT-WIDE PROTECTION STOPS CORROSION!

ATLAS CORROSION-PROOF CEMENTS

. . . complete line of sulfur silicate and resin based cements for plant-wide use in constructing corrosion-proof tanks, floors, pits, trenches and sumps.

ATLAS CORROSION-PROOF TANK LININGS

. . . natural or synthetic rubber and asphaltic materials designed to meet specific corrosive conditions within your plant and installed at the job site or in Atlas shops.

ATLAS RIGID PLASTIC STRUCTURES

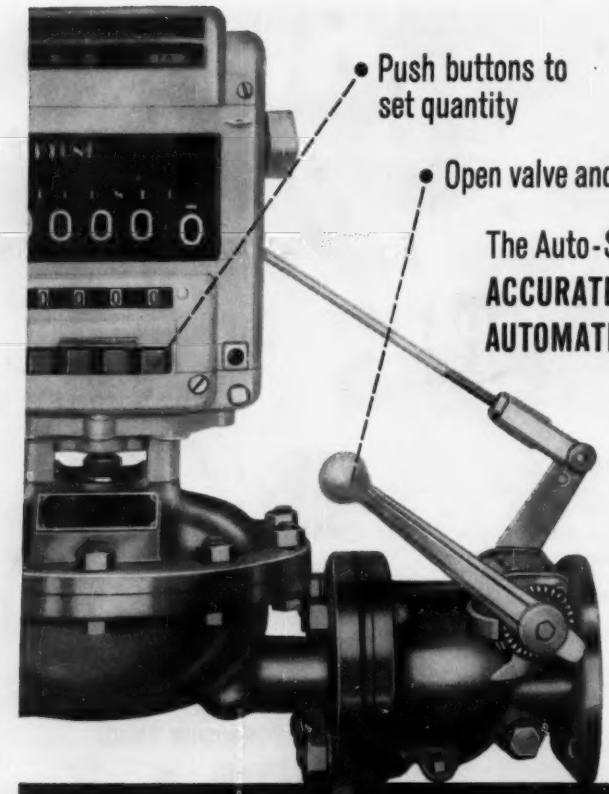
. . . corrosion-proof, self supporting polyvinyl chloride designed and fabricated for use as tanks, ducts and fume systems to meet your exact needs . . . plastic pipe systems to convey all your corrosives.

These products will give you permanent plant-wide protection against corrosives.

Write for Bulletin CC-3.

ATLAS MINERAL

MERTZTOWN, PENNSYLVANIA



NEW...STAINLESS STEEL AUTO-STOP LIQUID METER

It's here! *Automatic formula control* for the batching of corrosive liquids or liquids that must be kept free from contamination! It's the new Neptune Stainless Steel meter with all-stainless, Auto-Stop valve. The register watches the delivery, automatically trips the valve shut at the exact quantity. Valve is mechanically coupled...no inaccuracies due to time-lag in cut-off.

Saves time, ingredients, labor...puts end to spoiled batches...cleans up hazardous or messy conditions...provides accurate cost records. Accuracy is completely protected from effects of corrosion or corrosive wear. Only two moving parts in meter contact liquid. Gear train is outside the casing, isolated from liquid.

Size 1½", capacity 20 to 100 gpm. Also available with repeating Auto-Stop that "remembers" formula, and with ticket printing and electrical Auto-Switch combinations.

NEPTUNE METER COMPANY
Liquid Meter Division
47-25 34th St., Long Island City 1, N. Y.

neptune

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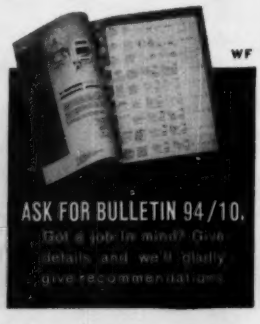

LITERATURE . . .

Pipe, PVC.....Koroseal PVC pipe is lightweight, resists acids, corrosion, aging, weather & abrasion. It will not support combustion, is an excellent insulator. Details.
1 *B. F. Goodrich

Piping.....Fluoroflex-T piping installations offer ease of installation, decreased maintenance, long equip. life etc. Resistant to any chemical up to 500 F. Bulletin.
44-45 *Resistoflex Corp.

Tube Fittings.....Poly-Flo tube fittings offer working pressures to 125 psi (¼" O.D.) 160 psi (5/16" O.D.); 100 psi (⅜" O.D.). Bulletin No. 3025 C for facts.
BR242 *Imperial Brass Mfg. Co.

Tubing.....Bi-Metallic Tubing is available in a variety of stainless-carbon, copper, brass and other combinations to solve dual corrosion problems. Details.
33 The Carpenter Steel Co.

Tubing, Pressure.....Seamless tubing is available in all common carbon, alloy & stainless grades, up to 11" O.D. and with wall thickness up to 3¼".
55 *Timken Roller Bearing Co.

Valve.....Sleeveline valves are designed & priced to replace ball valves, gate valves & lubricated plug valves wherever they are in use. Bulletin V/12a.
183 *The Duriron Co., Inc.

Valve, Diaphragm.....is available in a range of motor sizes from ½" through 6" valves. Wide choice of accessories such as: handwheel closing device, postioner, etc.
239 *Grinnell Company

Valves.....Ram type drain valves are designed so that in the closed position the piston or ram extends up into the tank. In open position, full flow is assured. Catalog.
L232 *Strahman Valves, Inc.

Valves, Ball......"Double-Seal" are available in Types 303, 316 & Alloy 20 Stainless Steel, Carbon Steel, Bronze, Ductile Iron, Aluminum & PVC. Technical information.
61 *Jamesbury Corp.

Valves, Control.....A Nodular Cast Iron valve is effective in temperature ranges of —20 F. to +650 F. and pressures up to 1,000 psi. Technical Paper TM-5 offered.
95 *Fisher Governor Co.

Valves & Fittings.....have high burst strength. All parts made of plastic. Newest literature on the complete line of PVC Valves & Fittings is now available.
50 *Walworth

Valves, Fittings, Unions.....Stainless and alloy steel materials are shown in their application to specific types of piping products in the 432-page Catalog F-10.
140 *Henry Vogt Machine Co.

Valves, Lubricated Plug.....available in either full or reduced port; rectangular, round, diamond & V-ports; also venturi, multiport & steam jacketed models. Cat. 400.
196 *W-K-M Div. of ACF Industries

Valves, Plug.....for asphalt, pitch, tar, sulphur, etc. Heavier than standard flanges provide ample strength for highly stressed bolting & rough handling. Catalog.
L275 *Parks-Cramer Co.

* From advertisement, this issue.

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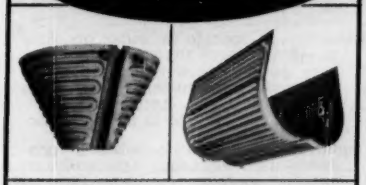
With Superior

DEAN PANELCOIL



Heating Conical Bottomed Tank | Heating Special Blender

Dean Panelcoil offers dollars and cents advantages over old-style pipe coil and conventional integral jacketing, regardless of shape or size. Low in cost. Faster, more efficient heat transfer. Easier to install. Lighter. Better in every way.

For complete engineering and pricing data, write for new Technical Data Sheets Nos. 15-60 series and Price Bulletin 259.

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Backed by 25 Years of Panel Coil Manufacturing

This is how you read 1 oz. on ordinary scales

This is how you read 1 oz.

ON DETECTO OVER-UNDER SCALES

Big 'travel' magnifies slightest weight discrepancy . . . prevents your profits dribbling away, ounce by ounce. Send for specifications.

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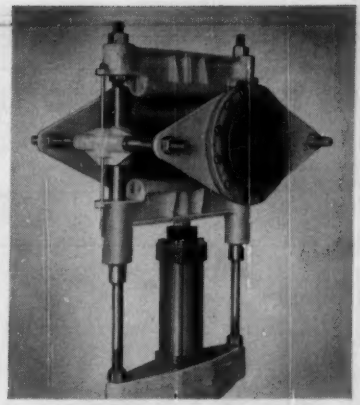
Dept. C-2, 540 Park Ave., Brooklyn 5, N. Y.



AUTOMATED *Hydral-60* PINCH VALVE SYSTEMS

Controlled circuitry for any operating requirements

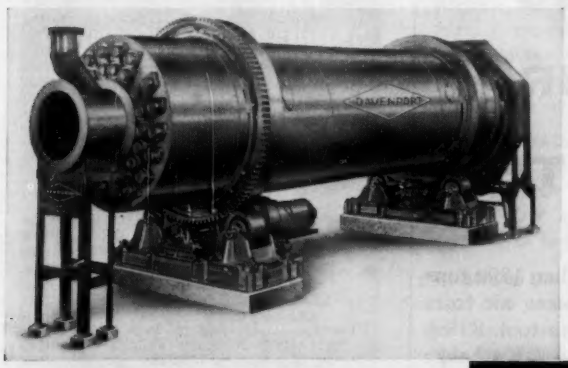
- The Massco-Grigsby Hydral-60 System consists of one or more pinch valves with a single automatically operated hydraulic pump.
- Hydraulic pump may be operated by electric motor or by air from normal plant supply system.
- Valves may be the same or different size.
- Valves in the system may be operated simultaneously or independently.
- Control valve may be manual or solenoid.
- Valves may be coordinated and interlocked with other plant equipment to automatically control tank levels, rate of flow, etc.
- Valves are self-supporting and may be operated in any position from horizontal to vertical.
- Valves may be independently controlled for normal or rapid closure.
- Valves may be held fully open, fully closed, or at intermediate positions.
- Remote control to meet individual requirements.
- Controls may be included for automatic emergency operation.
- 3" to 14" I.D. sizes, with 50, 100, and 150 psi line pressure ratings.
- Temperatures to 200° F.

WRITE FOR NEW CATALOG NO. 609

Manufacturing Division

MINE AND SMELTER SUPPLY CO.

3800 RACE STREET • DENVER, COLORADO
OFFICES AND AGENTS IN PRINCIPAL CITIES



COOLING PROBLEM?

"DAVENPORT" has the answer The above Rotary Water Tube, or Contact Type, Cooler installation is used in sodium chloride processing. Rotary Air Coolers and Rotary Indirect Air Coolers — "DAVENPORT" will engineer your weight, volume and heat transfer requirements.

Let our engineers consult with you on your Pressing, Drying and Cooling problems or send for our catalog "A". For quick reference consult your Chemical Engineering Catalog

DAVENPORT MACHINE AND Foundry Company

A DIVISION OF MIDDLE STATES CORPORATION

Davenport, Iowa, U.S.A.

DAVENPORT

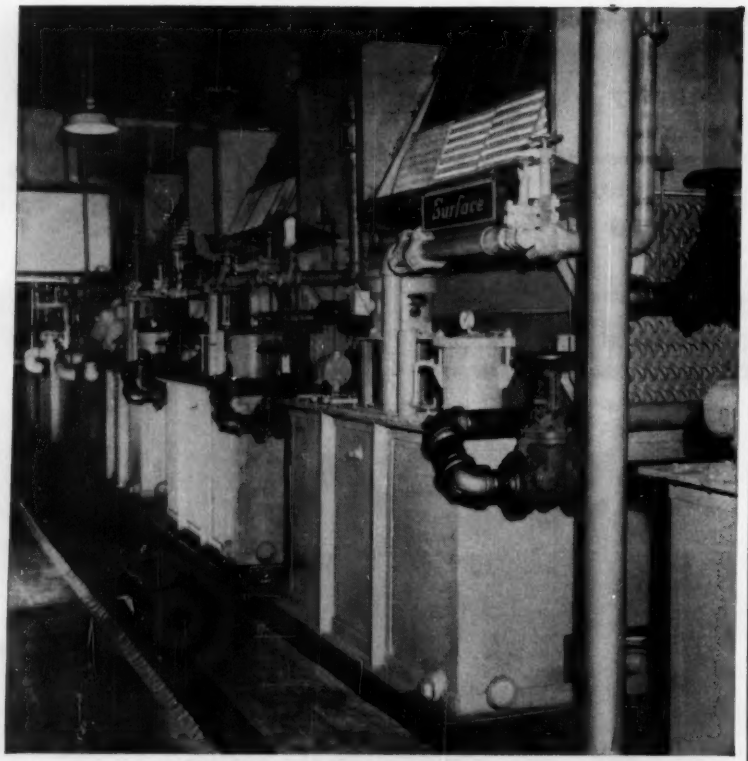
PRESSING — DRYING and COOLING Equipment

Continuous DeWatering Presses

ROTARY DRYERS Steam Tube, Hot Air and Direct Fire

Atmospheric DRUM DRYERS

ROTARY COOLERS Water and Air



120 GRAINS CUT TO 45 IN 200,000 cfm OF AIR WITH 85° TOWER WATER

Without Kathabar, this job would have taken 1800 tons of refrigeration, at about 35F and reheating air from about 45F to 98F! With Kathabar the job took 63 hp instead of 2000. Ask the men who have seen Kathabar Type C units serve for years with practically no maintenance. Write for specific information.

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Division of Midland-Ross Corporation MR

2380 Dorr St., Toledo 1, Ohio

Send facts on Kathabar systems for the following application:

name and title.....

company.....

street.....

city.....*zone*.....*state*.....

LITERATURE . . .

Valves, Solenoid.....Complete information on all models available. Also a 16-page brochure which lists over 500 corrosive media . . . coded for vorrect valve selections.
L230 *Valcor Engineering Corp.

Process Equipment

Blowers.....operate at wider pressure & speed ranges than any other rotary positive blower. Capacities of 22 production models range from 50 to 4,000 CFM. Information.
278 *M-D Blowers, Inc.

Centrifugals.....Batch-O-Matic provides high efficiency and constant quality control. Complete data on other features and applications on request.
248 *American Machine and Metals, Inc.

Collector.....The Amerjet will handle heavy dust loadings of materials of varying nature with a constant pressure drop that assures accurate control. Bul. 279.
56 *American Air Filter Co., Inc.

Connectors, Split-Eyelet.....for connection of spray nozzles, branch lines and equipment to piping & tubing carrying liquids, gases or air up to 250 psi. Bul. 93.
TL255a *Spraying Systems Co.

Demineralizers.....are available in mono-column, dual-column and multi-column types . . . in flow rates from 10 to 10,000 G.P.H. Full catalog information is offered.
L265 *Penfield Mfg. Co., Inc.

Filter.....With the EimcoBelt filter, operation is continuous, with no blinding and no fall-off in filtration rate. Bulletin F-2053 is offered.
Cover *The Eimco Corp.

Filter Cartridge....Micro-Wynd depth-type, disposable filter cartridge is designed & built with absolute control of all elements affecting filter performance. Data Folder.
22-23 *The Cuno Engineering Corp.

Filter Cartridge.....New principles of construction enable the AFCO Feutron filter cartridge to solve liquid & gas filtration problems. Complete data in booklet.
TL241 *American Felt Co.

Filters.....Details on how custom engineered Niagara Filters can help with your processing problems is contained in Bulletin NC-457 which is now available.
249 American Machine & Metal, Inc.

Gas Absorbers.....These units can be constructed of carbon steel, rubber lined steel, stainless, and lightweight reinforced plastic. Bulletin AP-225 gives details.
4 *Buffalo Forge Co.

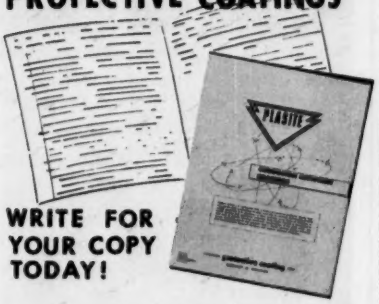
Gas Scrubber.....A copy of the brochure giving complete data on Chemico Venturi gas scrubbers is available. Also technical assistance on a specific problem.
53 *Chemical Construction Corp.

Hammer Mill.....with extra heavy manganese steel liners & breaker plates, oversize shafts, massive parts & reinforcements which defy shock & wear, reduce downtime. Catalog.
51 *Williams Patent Crusher

* From advertisement, this issue.

Simplify

YOUR SELECTION OF PROTECTIVE COATINGS



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PROVEN IN THE PROCESS INDUSTRIES

- STEEL TANK LINING
- CONCRETE TANK LINING
- PROTECTION OF STRUCTURAL STEEL, FUME DUCTS AND EQUIPMENT
- CONCRETE FLOORS
- TANK CARS

FOR IMMERSION SERVICE
FOR HEAVY DUTY MAINTENANCE SERVICE

COLD SET COATINGS

HEAVY BUILD using standard spray or brush methods.
WIDE CHEMICAL RESISTANCE to acids, caustic solvents, salts, de-ionized water, and aqueous solutions.
HIGH TEMPERATURE RESISTANCE not affected by thermal shock.
AIR DRY field applications.
EXCELLENT BOND — No Primers on white metal blasted surface.

OTHER PLASITE PRODUCTS INCLUDE: CAULKING COMPOUNDS
PRIMERS
BAKING COATINGS

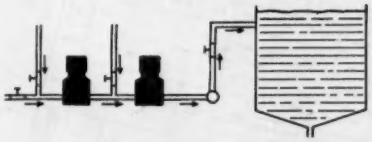
wisconsin protective coating corp GREEN BAY, WIS.

REPRESENTED IN PRINCIPAL INDUSTRIAL AREAS

PLASITE

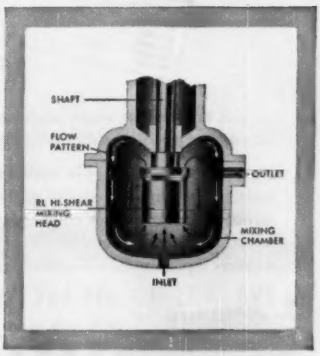
NEW SHEAR-FLOW CONTINUOUS MIXER

Finer, faster blending for in-line processing



- **CUT PROCESSING COSTS:** This compact and completely self-contained unit conserves space, eliminates large mixing and paddle tanks, speeds up pipe line processing, handles high viscosity material in a minimum of time and conveniently lends itself to systems requiring jacketed heating or cooling.
- **ELIMINATE COSTLY EQUIPMENT:** Incorporating the same design principle as the portable SHEAR-FLOW, the new continuous mixer is capable of mixing any liquid that can be pumped, with results better than or comparable to that of equipment costing considerably more.
- **VERSATILE ADAPTABILITY:** More than one unit can be installed in series or in tandem along the route of flow. The new continuous SHEAR-FLOW can also be mounted either vertically or horizontally.
- **HI-SHEAR HEAD:** The unique Hi-Shear Head with dual impellers and stationary stators creates a high turbulence and concentrated shearing action that results in finer, faster blending, homogenizing, emulsifying or dispersing. Mechanical shear is achieved through close tolerances between impellers and stators.
- **SIZE RANGE:** The new SHEAR-FLOW can be powered with motors ranging from 1 to 10 horsepower depending on the power requirement demanded by the application.

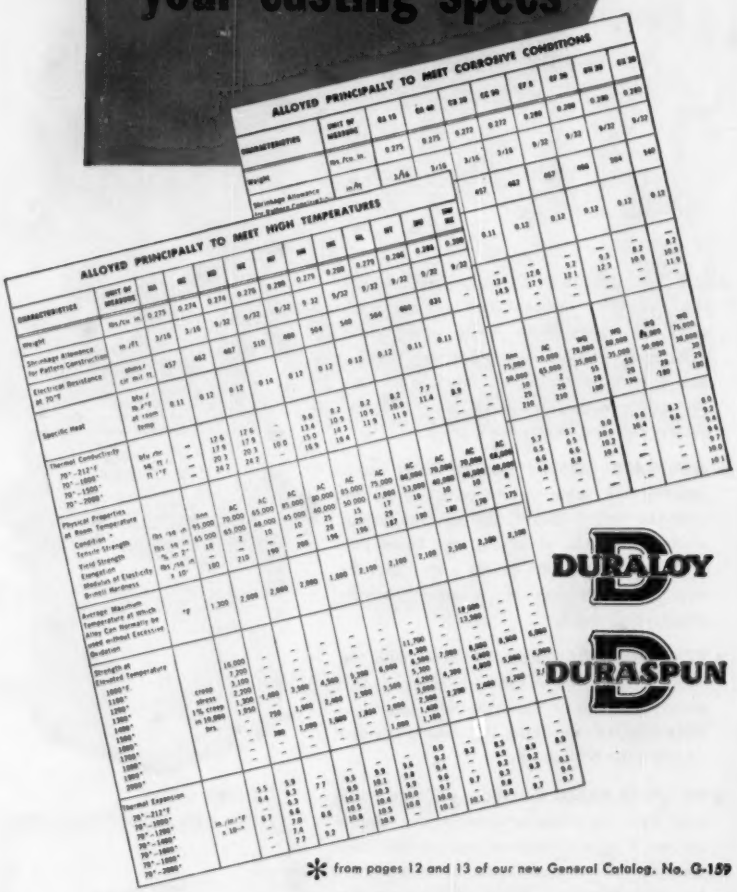
Write for free Bulletin No. RL-200



SHEAR-FLOW
GABB SPECIAL PRODUCTS INC.

GABB SPECIAL PRODUCTS INC.
Windsor Locks, Conn.

TABLES to help you select the proper alloy for your casting specs



from pages 12 and 13 of our new General Catalog. No. G-159

— and there's lots more useful information about high alloy castings in our up-to-date catalog describing Duraloy Service. SEND FOR YOUR COPY.

As one of the pioneers in both static (1922) and centrifugal (1931) high alloy castings, we have a wealth of experience to focus on your high alloy casting problem. Send for our catalog, study it, and then let us help you get the best alloying combination to solve your corrosion, high temperature and/or abrasion problem.

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LITERATURE . . .

Homogenizers.....provide the practical solution to particle control. Bulletins on Homogenizers H-55, Sub-Micron Dispersers SMD-55 & Colloid Mills C-57 available.
228a* Manton Gaulin Mfg. Co., Inc.

Impactors.....Full description of the CDL Series Impactors as well as other Pennsylvania Reversible Impactors is contained in Bulletin 6018.
65 *Pennsylvania Crusher

IMP Mill.....Catalog 87E shows the many applications of this multi-purpose grinding unit such as grinding, blending, separating, conveying, & drying.
138 *Combustion Engineering, Inc.

Line Strainers.....Special non-collapsing screen design for pressures up to 125 psi, for all pipe lines from ¼" to 6" size. Bulletin 94 for more information.
TL255b *Spraying Systems Co.

Lubricators.....Force-feed lubricators deliver just the right amount of oil to bearings, cylinders and packing. Unaffected by high steam, gas or air pressure. Catalog.
276 *Manzel

Mechanical Drive Dryers.....may be used for either drying or cooling & are available in direct or indirect types. They are built in standard lengths of 10 or 20 feet.
62 *The Jeffry Manufacturing Co.

Mills.....Complete information on "Jet-O-Mizer" Mills, "Jet-O-Clone" Dust Collectors, and testing and custom grinding services is now available on request.
198 *Fluid Energy Processing & Equip.

Nitrogen Generators.....produces 99.99% pure inert gas at about 20¢ per 1000 cu. ft. Standard sizes from 1000 CFH to 10,000 CFH. Bulletin No. 5901-N1 offered.
R230 *C. I. Hayes, Inc.

Pilot Plant Filters.....Bulletins and technical advice on the seven Pilot Plant Filters offered by FEinc. Available on a rental basis.
247 *American Machine & Metals, Inc.

Process Equipment.....The Mil-Reactor provides size reduction with mass transfer or chemical kinetic operations. Information.
57 *The Patterson Foundry & Machine

Purifiers.....Hi-eF purifiers prevent valuable particles from leaving evaporators & concentrators. Data on 13 types of purifiers, separators, mist extractors, scrubbers.
BL255 *The V. D. Anderson Co.

Rotary Airlock Feeders.....for dust control and pneumatic conveying. Bulletin P58, "How to Select A Rotary Airlock Feeder" is now available.
BL257 *Prater Pulverizer Co.

Rotary Blenders.....are available in 9 standard models with capacities to 900 cu. ft. Feature self-cleaning dust-sealed drum. Bulletin 080B for more information.
L277 *Sturtevant Mill Co.

Scrubbers.....Turbulaire-Doyle Scrubbers offer high collection efficiencies, fine particle collection, low liquid-to-gas ratio, etc. Descriptive literature.
233 *Western Precipitation

* From advertisement, this issue.

a vacuum pump as dynamically balanced as . . .

Engineered to give you years of vibration-free, superior operation, Stokes Series H Microvac pumps are the most advanced in their class. Exceptionally compact, Stokes pumps take up 50% less floor space than conventional vacuum pumps.

Learn all the reasons why Stokes offers you more pumping performance per dollar. Simply write: Vacuum Equipment Division, F. J. STOKES CORPORATION, 5500 TABOR ROAD, PHILA. 20, PA.

STOKES

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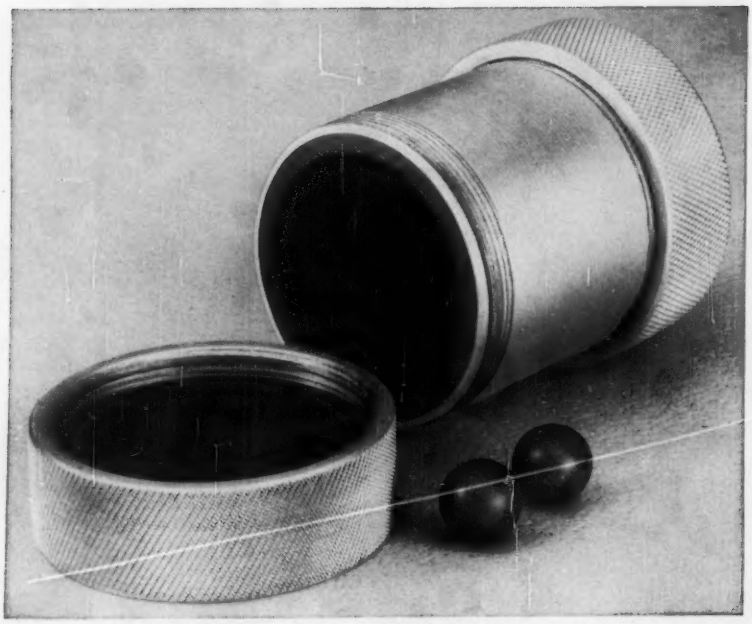
The air in this plant **has** to be clean, because they make precision electronic parts here. It is the Collins Radio Company manufacturing plant in Cedar Rapids, Iowa . . . completely air-conditioned, and electronically air-cleaned with Westinghouse Precipitron®. Collins finds that clean, controlled air pays for itself in fewer rejects, more reliable products, and in reduced absenteeism. Write for our booklet describing the advanced air engineering concept Collins has adopted — based on Westinghouse air handling and air cleaning products. Dept. LD08, Sturtevant Division, Hyde Park 36, Massachusetts. **YOU CAN BE SURE . . . IF IT'S Westinghouse**

J-80708



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Tungsten metals, silicon carbides, asbestos fibers, blast furnace slag, copper shot, alumina beads . . . are all conquered in this grinding vial used in a laboratory size mill.

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LITERATURE . . .

Separator....The Syncro-Matic Separator is available in single, double and triple screen decks, regular and stainless steel. Further information on request.
28-29 *The De Laval Separator Co.

Vibrating Mill....With grinding media occupying approximately 80% of mill volume, the grinding charge vibrates at high speed. Offers a wide range of versatility. Lit.
195 *Allis-Chalmers

Pumps, Fans, Compressors

Compressor.....The Model CRX produces pure, oil-free air without special filters. Sizes range from 100 to 1400 cfm. Additional information on request.
124 *Gardner-Denver Co.

Compressor, Cylinder.....Oil-less Cylinder Compressors can be furnished with tailrods & outboard crossheads to full support the pistons on all horizontal compressors.
120-121 *Chicago Pneumatic Tool Co.

Compressors.....Complete information on all types of high pressure, air and gas compressors is contained in a descriptive catalog which is available on request.
87 *Norwalk Co., Inc.

Compressors.....Complete separation of cylinder and crankcase protects product. Quiet, long lasting cushioned disc-type alloy steel valves. Bul. VE-100 and VE-102.
202 *Corken's Incorporated

Compressors, Piston....Non-lubricated ringless piston compressors are available for capacities up to 4000 cfm & discharge pressure up to 650 psig. Further information.
TR253 *Sulzer Bros. Inc.

Pump.....All-Chem rotary positive displacement pump for reduced viscosities and temperatures to 250 F, capacities to 10 gpm, pressures to 75 psi. Literature.
97b *Eco Engineering Co.

Pump.....Centri-Chem centrifugal pump handles most chemicals including slurries with particle size up to 1/16", as well as troublesome sticky fluids. Literature.
97c *Eco Engineering Co.

Pump.....Gearchem pumps for temperatures to 400 F, viscosities to 10,000 SSU, capacities to 10 gpm, pressure to 100 psi. Literature is available.
97a *Eco Engineering Co.

Pump.....Manilab all-purpose laboratory and pilot pump can handle severe corrosives. Capacities from 0 to 2 gpm, pressures to 100 psi. Reversible, self-priming. Lit.
97d *Eco Engineering Co.

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L263 *F. J. Stokes Corp.

Pumps.....A complete line of Pulsafeeder pumps with metered flow rates from a few drops to 15.7 gal. per minute; pressures up to 7000 psig. New Catalog 59.
209 *Lapp Insulator Co., Inc.

* From advertisement, this issue.

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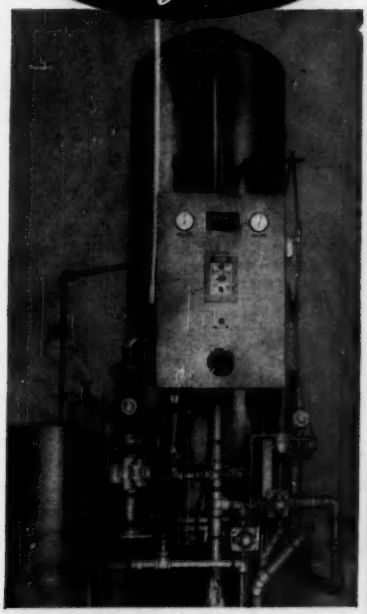

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64 *Aldrich Pump Co.

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49 *Robbins & Myers, Inc.

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118 *Goulds Pump, Inc.

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115 *Byron Jackson Pumps Inc.

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L242 *American Meter Co.

Steam Jet Exhauster.....A data sheet has recently been published on ejector types, special stock materials, and sizes stocked. Available or request. J-2.
137a *Schutte & Koerting Co.

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250 *Snap-On Tools

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224 *Independent Engineering Co., Inc.

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GR60-15

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(Continued from preceding page)

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1—700 sq. ft. Buflovak 304 S. S. forced circulation Evaporator.
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351 CFM	350 PSI	11-5x11 CP TCB-2
364 CFM	100 PSI	10x9 Joy WG 9
465 CFM	100 PSI	12x11-IR-ES CP.T. Worth HB
502 CFM	125 PSI	12x13 Worth HB
660 CFM	125 PSI	11½-7x7 Joy Wn 102
676 CFM	125 PSI	15-9¼x12 IR XCB
686 CFM	100 PSI	14x13 Ing. ES
877 CFM	125 PSI	17-10½x14 IR, XRB
1050 CFM	60 PSI	13-13x12 IR-XRE
1055 CFM	110 PSI	18-11x12 CP-OCE
1665 CFM	(actual) 100 PSI	C300-300H Fuller
2200 CFM	125 PSI	26-15x18 CP-OCE
2520 CFM	125 PSI	17-10¾x8 Clark CMA-4L

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE J ON READER SERVICE CARD

LOEB OFFERINGS

Autoclave: 50 gal. Struthers Wells, st. st.
Centrifugal: AT&M 60" st. st. perf.
Dewaterers: Davenport 3A, bronze hd. 3 hp.
Disintegrator: Rietz RD18P, 75 hp.
Dryers: Devine 2 x 4' vac. drum. st. steel.
Dryers: Bowen lab. spray, st. steel.
Dryer: American atmospheric, 24 x 48".
Column: 24" x 22', 316 stain. steel.
Evaporator: Buflovak st. st., 94 sq. ft.
Filter: Sweetland #5 st. st. lined.
Filter: Oliver precoat 12 x 2" st. steel.
Filter: Eimco st. st. drum 16" x 12".
Filter Press: Shriver 24" St. steel.
Homogenizers-Disperser: Tri-Homo #10,#4.
Homogenizers: 25, 50, 125, 200, 1200 GPH.
Kettles: st. steel with and without ag.
Dopp 150 gal. dbl. act. agitator.
Mill: Fitz model D-6 st. steel, 7½ hp.
Mill: J. H. Day 16 x 40" 3-roll high speed.
Centrifugal: Tolhurst 48" st. steel.
Mixers: Dbl. and sgl. arms sigma blade.
Dry Powder, various sizes.
Pumps: Rotary, gear, centrif., vacuum.
Percolator: Pfaudler 300 gal. st. steel.
Dryer: Proctor & Schwartz 6-tray st. steel.
Tablet Press: Stokes DD2, 23 station.
Vacuum Pans, 42" and 72" stain. steel.

LOEB · TELEPHONE SEntry 8-1431
EQUIPMENT SUPPLY CO.
820 WEST SUPERIOR ST. CHICAGO 22, ILLINOIS

CIRCLE L ON READER SERVICE CARD

FOR SALE

2 Drever Ammonia Dissociators, 3000 CFH each, designed for 220/3/60 current, each with 3 single phase transformers from 440 volts, connected load 60 KW. Each complete with panel board with Brown circular chart recording controller, Brown indicating controller, contactor, plus numerous high pressure fittings. May be inspected in Cleveland.

FS-5677, Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

CIRCLE H ON READER SERVICE CARD

Buffalo 32"x90" Double Drum Dryer
New 4000 gal. Stainless Tank
Spr. Wald 10,000# Spiral Mixer
SEND FOR LISTINGS

STEIN EQUIPMENT CO.
107—8th Street Sterling 8-1944 Brooklyn 15, N. Y.

CIRCLE K ON READER SERVICE CARD

SELL OR TRADE YOUR SURPLUS UNITS BEFORE INVENTORY TIME-COMING UP

EVAPORATORS — DRYERS

Buflovak S/Steel Thermo-Recompression Evaporator; Sanitary with all accessories.
Buflovak S/Steel Dbl. Effect Evaporator Model 81½-60 D.
Stokes Rot. Jacketed: 34"x10'.
Pittsburg Lectro Dryers, Bac 25 and BWC 3400.
Devine Vac. Chamber Dryers, Double Door Model No. 36.
Stainless Lab. Drum Dryer, 8"x11½" complete.
Bowen S/S Lab. Spray Dryer.
Louisville S/S Rotary Dryer, 30" x 28'; Indirect fired.
Louisville MONEL Rotary Steam Tube; 54" x 35'.

MILLS—PULVERIZERS

2 Stainless Micronizers 30".
Ball Mills and Pebble Mills by Abbe, Patterson, International some Jacketed; up to 8'x8'.
Mikro Pulverizers up to No. 4's.
Fitzpatrick Comminutators; Models D, X and C; motorized.
American Ring Roll Crusher; 50 HP.
Mikro S/S Atomizers; Nos. 6 and 5.
Raymond Imp Mills; many sizes.
Williams Hammer Mills to 60 HP.

REACTORS — PRESSURE VESSELS

2 Stainless 400 gal. Reactors Jktd. Agtd. by Patterson and Struthers Wells.
Stainless Reactor, 2000 gal. Fully Jktd. Agitated.
Nickel Clad Reactor, 7'x11'6".
2 MONEL Reactors; 2800 gal. 6'8"x13"; ASME Jktd. & Intern.
3 Stainless Vert. Pressure Tanks; 42"x10'; closed dished heads.
6 Heavy Duty Stainless Tanks; 850 gal. with S/S Agitators.
Pfaudler Gl. Lined Reactors; all sizes from 50 to 1000 gal.
Mojonnier Stainless Vac. Pans; 3'x10' and 6'x12'; others.

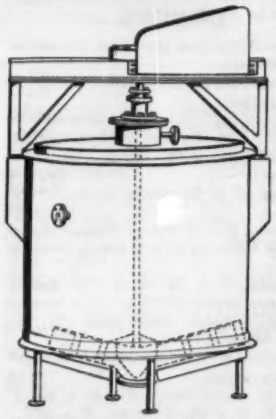
CENTRIFUGES

Stainless Centrifugals from 30" to 60"; A.T.&M. Tolhurst, Fletcher, etc.
2 Sharples Stainless Steel Model PM14 Super-D-Canters.
4311 S 1 Sharples C 27 Super-D-Hydrator in Type 316 Stainless with 40 HP Motor.
5147 S 13-14 Two Bird Continuous Screen Type Horizontal Centrifuges; Monel & S.S.; 24" x 24".
2 Bird Rubber Covered, 48" with Plows; Fume Tight; 40 HP.

JUST ADDED TO STOCK

Patterson Conaform S/S Vac. Blender, 13.7 cu. ft. Jacketed.
Stokes Model 138 D Vacuum Shelf Dryer; Complete.
Stainless Lab. Drum Dryer; 8" x 11½".
3 Stokes Model 280 Preform Presses.
Royle No. 1 (2") Extruder; electr. heated.

SAVE $2100 on FIRST'S WEEKLY FEATURE SPECIAL



Call it what you will—YOU name it. It's a Dorr-Oliver 500 Gal. Stainless Steel (¼") Reaction Vessel; It may be used as a Thickener or a Clarifier or a Precipitator.

MIXERS ALL TYPES

Baker-Perkins Jktd. 5 gal. UNE-7, Dbl. Arm Mixer with pressure cover; 30 HP.
Readco Jktd. 15 gal. Dbl. Arm Sigma Blade Mixer.
Stainless Steel 150 gal. Jktd. Dbl. Arm Mixer with Vac. Cover; Hydr. Tilt;
Other Baker Perkins Jktd. Mixers, 200 and 300 gal.
J. H. Day Cincinnatus Dbl. Arm Mixer; 300 gal. STAINLESS Jacketed.
NOW IN STOCK for IMMEDIATE DELIVERY. ALL SIZES FALCON Ribbon Blenders in Steel or Stainless.

FILTERS — FILTER PRESSES

4 Pressure Filters 30"x56" Type 316 Stainless; 100 sq. ft.
Sparkler S/S Filter Model 14 S 4.
Sparkler Steel Filter Model 33 S 17.

OLIVER PRECOAT FILTERS

3"x2" Monel. 5'3"x8' Stainless.
(2) 5'3"x3" Steel or Rubber.
Feinc S/S Rot. Vac. Filter 3'x1'.
Oliver Cont. Rot. Vacuum Filter.
Panel Type; 8'x8' and 8'x10'.
S/S Nutsche Type Filter; 6'x2'.
Bowser Filter with Pump: 2000 GPH.
Shriver and Sperry Plate & Frame Filter Presses up to 42" in Cast Iron, Stainless, Ni-Resist, Rubber Covered or Wood; all types.

FIRST MACHINERY CORP.

209-289 TENTH STREET, BROOKLYN 15, N. Y.

FMC Pays MORE For Your Surplus

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CIRCLE M ON READER SERVICE CARD

LIQUIDATION ALCOHOL PLANT OMAHA, NEBRASKA

MAJOR ITEMS

5—Buflovak 42" x 120" dbl. drum dryers, ASME 160#
2—Bonnet 7' x 60' rotary dryers,
1—Bonnet 6' x 52' rotary dryer,
9—Davenport #1A #2A dewatering presses
2—French Oil screw extrac. presses,
2—Sweetland #12 pressure filters,
3—Lawrence 4" x 3" stainless centrif. pumps, 275 GPM @ 40' head
6—Shriver 48" Cast Iron P. & F. filter presses, (50) chambers, hydraulic closure, closed deliv.
2—19,900 sq. ft. quadruple effect calandria type evaporators, copper tubes, cast iron bodies, with preheater & finishing pan
6—Ansonia 691 sq. ft. dbl. pipe coolers, copper tubes
3—American 654 sq. ft. spiral steel heat exchangers
1—1500 sq. ft. horiz. exchanger, (480)—¾" OD copper tubes, copper T. S. & shell, steel heads
18—Tubular heat exchangers, copper tubes: 1500, 1350, 1130, 637, 380, 290, 184, 176, 156 sq. ft.
1—ACME 96" dia. x 44' high copper beer still column, (20) perforated & (4) bubble cap trays
5—Leader Iron 96" dia. steel rectifying columns, 44' & 51' high, bubble cap trays
2—9500 gal. horiz. cookers, 9' dia. x 20' long, ½" shell & dished heads, agits.
4—Wallace & Tiernan auto. bulk handling scales
10—Forster hammermills, #8 & #6, 100 & 75 HP.
1—Stedman 36" dia. 3-row cage mill disintegrator
1—Prater "Blue-Streak" pulverizer,
1—Fuller 12 x 20 pos. press. blower
2—Allis-Chalmers Inter-plane grinders, 100 HP
1—"Jay Bee" #4 hammermill,
9—Davenport 5' x 25' inclined "slop" screens
2—Warren 12" x 12" cent. pumps
250—Steel centrifugal pumps, 1" to 12", 1 HP to 150 HP
2—Aldrich vert. triplex plunger piston-type pumps, steam drive
100—Steel & stainless steel screw conveyors, up to 161' long
5000 HP—TEFC motors, 3/60/220-440/, to 150 HP
20—Steam turbines, to 150 HP
200—Steel tanks & bins, all sizes
12—300 amp. portable welders, elec. & gasoline

SEND FOR CIRCULAR #960-A

PERRY EQUIPMENT CORP.

1413-21 N. Sixth St.
Philadelphia 22, Pa.
Phone POplar 3-3505

CIRCLE N ON READER SERVICE CARD

AMERICA'S LARGEST STOCK

All Types of Chemical-Process Equipment!

PRICED RIGHT FOR IMMEDIATE DELIVERY!

RECENT STOCK PURCHASES!

5—1350 gal. T347 SS jacketed kettles, agit.
2—100 gal. T304 SS jkt. reactors, ASME, UNUSED
1—1800 gal. T316 SS jacketed reactors, VACUUM.
2—Mikro #3TH pulverizers, stirrup hammers
1—4300 gal. T304 SS horiz. tank, ASME 50# WP
1—Stokes model #R single-punch tablet press
3—Komarek-Greaves 160,000 psi briguette presses
1—Patterson 6'x10' jkt. pebble mill, porcelain
1—American 42"x120" double drum dryer, ASME
1—Bird 32"x50" T316 SS contain. centrifugal
1—Raymond 50", 5-roller hi-side mill, dbl. whizzer
1—J. H. Day #8 Cinc., 150 gal. dbl. sigma mixer

STAINLESS STEEL TANKS

1—5700 gal. horiz., T304 SS, 6'-4"x24', UNUSED
2—4500 gal. vert., T304 SS, 8'x12', UNUSED
1—4300 GAL. HORIZ., T304 SS, 6'x20', DISHED HEADS
1—3700 gal. vert., T304 SS, 6'x17', VACUUM
1—3400 gal. horiz., T304 SS, 6'x16', dished heads
1—3300 gal. vert., T304 SS, 6'x14', dished heads
1—3000 gal. vert., T304 SS, 6'x15', coils, VAC.
3—2750 GAL. VERT., T316 SS, 7'x8', DISHED HEADS
1—2500 gal. vert., T316 SS, 7'x7', dished heads agit.
2—2300 gal. vert., T316 SS, 7'x8', coils, agit.
4—2250 GAL. VERT., T316 SS, 7'x6'-3", DISHED HEADS
1—2100 gal. vert., T316 SS, 6'x9'-10", cone bottom
1—1750 gal. vert., T304 SS, 5'x12', coils, VAC.
12—1750 gal. vert., T304 SS hoppers, 235 cu. ft.
1—1250 gal. vert., T304 SS, 5'x12', coils, VAC.
2—1000 GAL. VERT., T304 SS, 5'-5"x6'x2", UNUSED
6—685 gal. vert., T316 SS, 3'x13', coils

KETTLES-REACTORS

1—3500 GAL. STRUTHERS-WELLS, T316 SS JKT. REACTOR, AGIT.
1—1900 GAL. T316 SS JKT. REACTOR, 5 HP AGIT., VACUUM
5—1350 GAL. T347 SS JKT. KETTLES, ANCHOR AGIT.
1—1000 gal. Dopp cast iron kettle, jkt., 25 HP agit.
1—750 gal. T304 SS jkt. fermenter, ASME, 10 HP agit.
1—750 gal. Pfaudler glass-lined jkt. reactor
1—600 gal. Pfaudler glass-lined jkt. reactor
1—600 gal. T304 SS jkt. crystallizing kettle, agit.
2—500 gal. Pfaudler glass-lined jkt. reactors, agit.
6—465 gal. T304L SS jkt. reactors, 175# WP
2—125 gal. T316 SS jkt. fermenters
2—100 GAL. T304 SS JKT. REACTORS, ASME, VAC., UNUSED

FILTERS-CENTRIFUGALS

2—Oliver 5'-3"x3' rot. vac. filters, T316 SS, precoat
1—Oliver 5'-3"x8' rot. vac. filter, precoat, UNUSED
1—Oliver 5'-3"x8' rot. vac. filter, monel screens
1—Niagara #510-28, 510 sq. ft. T316 SS leaf filter
2—Sweetland #12 steel filters
6—Shriver 48" cast-iron P. & F. filter presses, (50) chambers
22—Sharples #AS-16V super centrifugals, inconel, vapor-tite, sludge disch. frame
2—Sharples #C-20 Super-D-Hydrators, T316 SS
2—Sharples #C-27 Super-D-Hydrators, T316 SS
1—Bird 18"x28" T304 SS contin. centrifugal
3—Bird 24"x24" monel centrifugals, type CH
1—Bird 32"x50" T316 SS contin. centrifugal
1—Tolhurst 48" susp. basket centrif., T304 SS
6—AT&M 40" susp. basket centrif., T304 SS
1—Bird 40" susp. basket centrif., steel
1—Fletcher 40" susp. basket centrif., steel
2—AT&M 32" susp. basket centrif., T304 SS
1—Tolhurst 26" susp. basket centrif., steel
1—AT&M 12" susp. basket centrif., T304 SS

HEAT EXCHANGERS-CONDENSERS

1—1960 sq. ft., T316 SS exchanger, ASME 75# WP
1—1450 sq. ft. T316 SS condenser, 1" OD tubes
1—880 sq. ft. T316 SS condenser, 1" OD tubes
3—800 sq. ft. T316 SS condensers, ⅝" OD tubes
1—730 sq. ft. T316 SS condenser, 1" OD tubes
5—T316 SS condensers: 510, 427, 425, 410, 400 sq. ft.
25—T316 SS condensers: 290, 277, 264, 250, 200, 185, 165, 150, 145, 105, 83, 73, 54, 52, 30 sq. ft.

PERRY EQUIPMENT CORPORATION

1413-21 N. SIXTH ST. PHILADELPHIA 22, PA.

Phone POplar 3-3505

CIRCLE 0 ON READER SERVICE CARD

LIQUIDATING

10 MILLION DOLLAR **CHEMICAL PLANT** NORTH JERSEY AREA

TYPE 316 STAINLESS STEEL EQUIPMENT

1—2600 gals. type 316 SS vertical vacuum receiver
1—Struthers Wells 150 gal. type 316 SS pressure vessel, 500# pressure, ASME Code National Board
2—Rubber lined horiz. storage tanks, 5500 gals., working pressure 45#
6—Rubber lined vertical storage tanks, 4500 gals., working pressure 45#
2—Rubber lined vertical storage tanks, 2500 gals., working pressure 45#
2—Buflovak type 316 SS jacketed rotary vacuum dryers, 5' x 30', complete with 25 HP explosion proof motors and drives
3—Type 316 SS Ter-Meer continuous type centrifuges, 4' dia. bowls, complete with motors.
1—Readco stainless steel horiz. blenders, 450 cu. ft. working capacity, complete with 75 HP motors
3—Mikro Model 3TH stainless steel pulverizers, complete with 40 HP explosion proof motors
3—Nash SH-6 SS vacuum pumps, complete with 20 HP motors
2—Aldrich Groff type 316 SS hydraulic triplex pumps, size 2¾" x 4" at 500 psi
2—Powell type 316 SS, 10" hyd. oper. flanged and gate valves
3—Tyler type 38 tandem SS Hummer screens, size 42" x 9'8"
3—Williams type 316 SS hammermills with 100 HP motors
2—200 gals. type 316 SS jacketed kettles
500 tons of type 316 SS pipe, fittings and valves, from 2" to 6"
500 tons of structural steel
4—Patterson Kelley SS heat exchangers, 235 sq. ft. and 300 sq. ft.

R. GELB & SONS, Inc.

U. S. HIGHWAY 22, UNION, N. J. MUrdock 6-4900

CIRCLE P ON READER SERVICE CARD

CHEMICAL PLANT SALE

Everett, Mass.

B&P Ter Meer S30 Centrifuge 316 S.S.
Sharples C-27 Centrifuge 316 S.S.
Elmco 4'x2' Rotary Dewaterer 316 S.S.
S.S. Centrifix Eliminator 42"x12'6".
Bubblecap Columns 7'x25'—9 trays; 5'x88'—35 trays; 3'x38'—35 trays.
Baker Perkins 18DIM 300 gal. Mixer.
100 Steel Tanks 1000 to 350,000 gal.
Swenson 24"x20' jkt. S.S. Crystallizers.
Swenson Evaporator 425 sq. ft. Stainless.
Penna. SX13 Hammermills, 400 HP.
Heil Patterson Crushers, 100 HP.
Koppers 36"x42"—2 Roll Crushers.
Centrif. Blowers 23M; 29M; 50M, CFM.
10,000 ft. Trough Conveyor 30"; 36"; 42".
Stainless Centrif. Pumps 2"x2" to 6"x5".
Patterson Uni-Power Drives 1 to 20 HP.

STAINLESS TYPE 316 TANKS

17,500 gal. 15'x16'OA Flat top, cone bot.
11,500 gal. 12'x15'OA cone bot. 15 HP Agit.
10,500 gal. 10'x23'OA dish top, cone bot.
400 to 850 gal. (10), Some Agitated.

HEAT & POWER CO., INC.

60 E. 42nd St., N. Y. 17 MU 7-5280

SALES AGENTS for
HARCON LIPSETT JOINT VENTURE

CIRCLE U ON READER SERVICE CARD

TRY IT BEFORE YOU BUY IT

GOOD USED MACHINERY ON APPROVAL

1—Oliver 3' dia. Horizontal Filter type 316 Stainless Steel
2—Niagara 510-28 Vertical Filters 500 sq ft Auto Sluicing SS lvs
3—Shriver 36" x 36" Iron Filter Presses, 60 plts 60 frms each
16—New Am. Heat Reclaiming Heat Exchanger. 55 & 120 sq ft
1—Downington Nickel Shell & Tube Heat Exchanger. 1" tubes 50 sq ft
2—6' x 50' Rotary Flame Dryers ½" riveted shell. Comp/equipped
1—Robinson 36" x 8' Dbl Ribbon Mixer. 10 HP Ghd Motor
1—Dorrco 60' dia x 38' high. 3 deck Thickener. Comp/equipped

MACHINERY AND EQUIPMENT COMPANY

123 Townsend St. · San Francisco 7, California

CIRCLE Q ON READER SERVICE CARD

IMMEDIATE DELIVERY

CENTRIFUGE: Sharples Super Decanter Model PN-14; all S/S.
MIXERS: Grede & Gray 4,000# horizontal ribbon blender; S/S; Hobart, Mixanett, lab. size mixer; J. P. Devine 300 gal. ribbon mixers jacketed for 100 psi.
FILTERS: Niagara Style 8 horizontal type; Sparkler Models 14-4; 330-7; 3326R.
MILLS: J. B. Sedburry 4 WDC; Gruendler No. 1 Supermaster; Mikro 2 th; Prater Blue Streak.

AARON EQUIPMENT CO
9370 Byron Street
Schiller Park, Illinois
Gladstone 1-1500

CIRCLE V ON READER SERVICE CARD

FILTER PRESSES—6" lead P&F w/pump, 18x18 (26 chamber), 30x30 (11 chamber)
MILLS—Hardinge Conical, 3'x8", 3'x24", 5'x22", 8'x36", 8'x48", 6'x12' rod w/200 HP
VACUUM PUMPS—115 CFM Beach Russ RP w/5 HP motors, Leiman 105 CFM, Derr Oliver 200 CFM-piston
DRYERS—ROTARY—24"x22', 3'x24', 4'x40' 5'x50', 7'x58', all w/motor drives.
MIXERS—New 3 qt. sigma/jacketed, 5 gal. Bramley 5 HP vac./jack., 12 gal. sigma, 22 cu. ft. ribbon blender.
E. W. LAWLER has stopped piloting International Jet Liners—Full time super service now for YOU.
MIKRO BANTAM w/vari feed drive, 4TH Mikro (unused) w/Mikro collector & 3x5 Tyler screens for closed circuit.

LAWLER COMPANY

Durham Ave. Liberty 9-0245 Metuchen, N. J.

CIRCLE R ON READER SERVICE CARD

STAINLESS STEEL TANKS

24" x 45", 10 gauge, 400 PSI, type 304, ¼" pipe thread each end. *NEW*, $300 value, $99.50. Size 8½" x 18", 16 gauge, $14.50. Case of 8, $14.25. F.O.B. Baton Rouge, Louisiana.

Illinois Mfg. & Supply Co.
1829 S. State, Chicago 16, Illinois

CIRCLE S ON READER SERVICE CARD

VALUES GALORE—BUY NOW!

2—Kent High Speed 3 Roll Mills 14"x30".
2—30" S.S. Bubble Cap Columns.
1—Rotex Screen 20"x48"—two deck.
4—Rotex Screens 30"x96"; 40"x84"; 60"x84".
1—Day 50 Gal. S.S. Sigma Blade Mixer.
2—S. S. Spiral Blenders 1000 & 1800# Cap.
2—Spiral Blenders 30 cu. ft. Jacketed.
1—Raymond 36" Double Whizzer Separator.
1—Patterson 5' x 6' Jack. Ball Mill 25 H.P.
1—Autoclave 30 Gal. S.S. 1000 psi.
1—Cyclotherm Boiler 20 H.P. Oil Fired.
5—Hercules Pressure Filters 16" & 3" Sq. Type 316 S.S.
5—Worthite S.S. Pumps 8"x6"; 3"x2"; 2"x1½".
Conveyors, Labelers, Agitators, etc.

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Used Div. of HARING EQUIPMENT CORP.
91-93 New Jersey R.R. Ave. Newark 5, N. J.
Market 2-3103

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Chemical Engineering
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CHEMICAL PROCESS EQUIPMENT

2—Pfaudler type 316 SS jacketed kettles, 100 and 200 gals.
1—Patterson type 304 SS jacketed autoclave, 10 gal. with agitator and drive, 600 psi internal, 175 psi jacket
2—Baker Perkins 50 gal. double arm sigma blade mixers with 50 HP drives
1—Pfaudler glass lined 100 gal. jacketed reactor with impeller type agitator and drive

AUTOCLAVES, KETTLES AND REACTORS

1—Oat 10 gal. type 316 SS jacketed autoclave, 150# internal pressure and jacket, complete with agitator and drive and Dowtherm unit.
2—Monel 2500 gal. jacketed autoclaves, 175# jacket and internal pressures
2—Struthers Wells type 316 SS reactors, 2000 gal. complete with agitators and drives
2—Blaw-Knox 600 gal. steel reactors, complete with double motion agitators and drives, 50# jacket, 50# internal
1—Patterson SS 40 gal. jacketed reactor, complete with agitator and drive, 50# jacket and 50# internal
1—Van Alst 250 gal. SS. jacketed kettle, complete with SS column and condenser
10—Pfaulder glass lined jacketed reactors, 30 to 750 gal.
4—Alloy Fabricators type 316 SS vacuum receivers, 2600 gal.

DRYERS

1—American 42" x 120" double drum dryer, ASME, N.B., complete with drives and motors
1—Allis-Chalmers SS 6' x 50' rotary dryer, complete
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
3—Link Belt steel roto louver dryers, Model 207-10, 310-16, 604-20
1—Hersey SS rotary dryer, 3' x 21'
1—Buflovak SS jacketed rotary vacuum dryer, 3' x 15'
1—Proctor & Schwartz SS apron dryer, 2' x 20'
3—Buflovak Steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
1—Traylor 4' x 40' rotary dryer
1—Stokes Model 59DS steel rotary vacuum dryer, 5' x 30'
1—Western Precipitation Corp. S.S. pilot plant spray dryer, Type N-2
1—Bowen SS pilot plant spray dryer
2—Buflovak SS rotary vacuum dryers, 5' x 30'

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
12—Sweetland #12 filters with 72 SS leaves
1—Niagara SS filter, Model 510-28
1—Oliver horizontal filter, 3'
1—GATX SS pilot Plant filter, 2' x 6"
1—Oliver SS rotary vacuum pressure precoat filter, 5'3" x 8'
1—Oliver SS rotary vacuum filter, 3' x 4'
10—Shriver plate and frame filter presses, 12" to 42"
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers

CENTRIFUGES

1—Fletcher 48" SS under-driven centrifuge, complete with perforate basket and motor
1—AT&M 48" suspended type centrifuge, complete with plow, motor and imperforate basket
7—Western States 40", type 316 SS, suspended type centrifuges, complete with perforate baskets, plows and 40 HP motors

THE GELB GIRL—DECEMBER 1960

2—Fletcher 40", rubber covered, under-driven centrifuges with perforate baskets and motors
1—AT&M type 316 SS, suspended type centrifuge, complete with 26" perforate basket, plow and motor
4—Tolhurst 40" center slung rubber covered centrifuges, with perforate baskets and motors
3—Tolhurst 30" center slung, rubber covered, centrifuges, with perforate baskets and motors.

MIXERS

1—Patterson-Kelly steel twin shell blender, 150 cu. ft., w/motor
1—Robinson SS 125 cu. ft. horizontal double ribbon blender
1—Cleveland SS double cone blender, 85 cu. ft. complete with drive and motor
2—Sturtevant #7 dustite rotary batch blenders, NEW
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Baker Perkins Size 16, Type UUEM, 150 gal., jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor
1—Baker Perkins 20 gal. SS jacketed vacuum double arm mixer
1—Stokes SS granulating mixer, Model 21-J

MISCELLANEOUS

1—Vulcan SS bubble cap column, 4' x 25 plates
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 and 600 sq. ft.
1—Downington type 316 SS heat exchanger, 750 sq. ft.
1—Griscom Russell stainless steel heat exchanger, 900 sq. ft.
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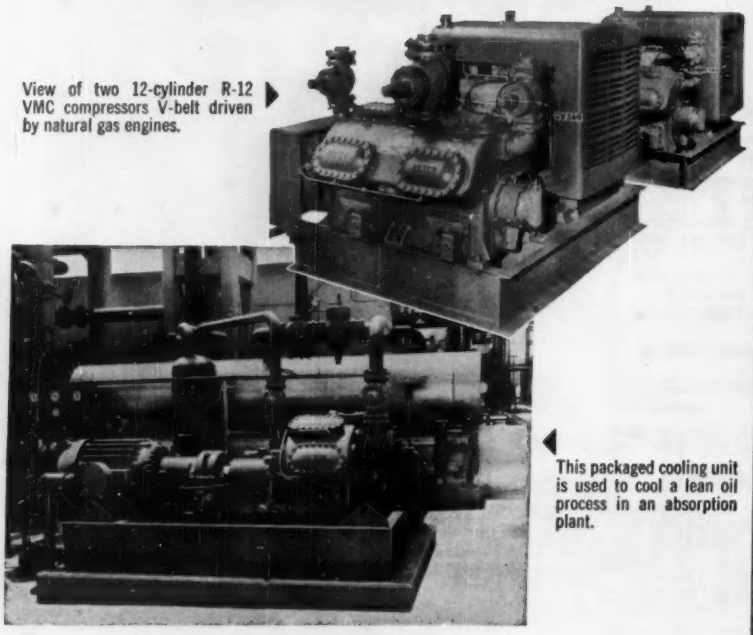
View of two 12-cylinder R-12 VMC compressors V-belt driven by natural gas engines.



This packaged cooling unit is used to cool a lean oil process in an absorption plant.

Both *packaged cooling units* and *packaged compressor units* for use with remote heat exchangers are available from Vilter for installation at the actual site in your process where cooling is required. Custom designed to fit your load at your conditions for maximum performance, these rugged, heavy-duty, long-life Vilter units simplify handling, erection and relocation.

Typical of the equipment Vilter supplies are the units shown above. The packaged compressor units are 12-cylinder, R-12 VMC compressors, V-belt driven by natural gas engines. The packaged cooling unit is used to cool a lean oil process in an absorption plant and incorporates an 8-cylinder, R-22 VMC compressor, a 20″ x 14′ long chiller and a 16″ x 12′ long condenser.

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Many leading names in the chemical, petrochemical and petroleum industries look to Vilter for their special refrigeration, heat exchanger and vessel needs. Why not consult with Vilter about your problem?

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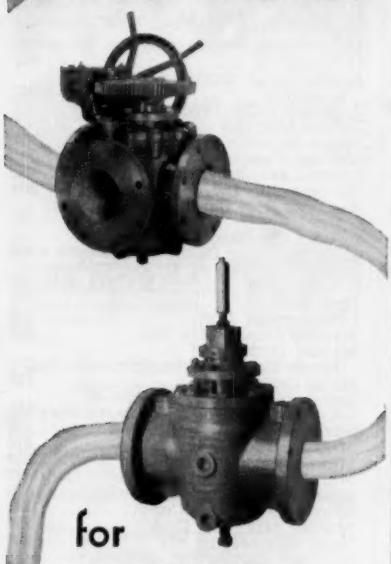

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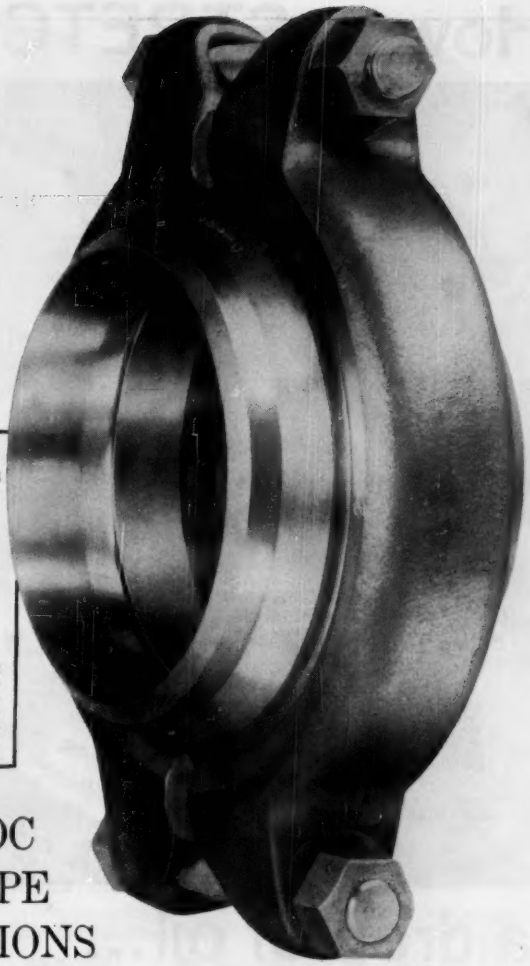

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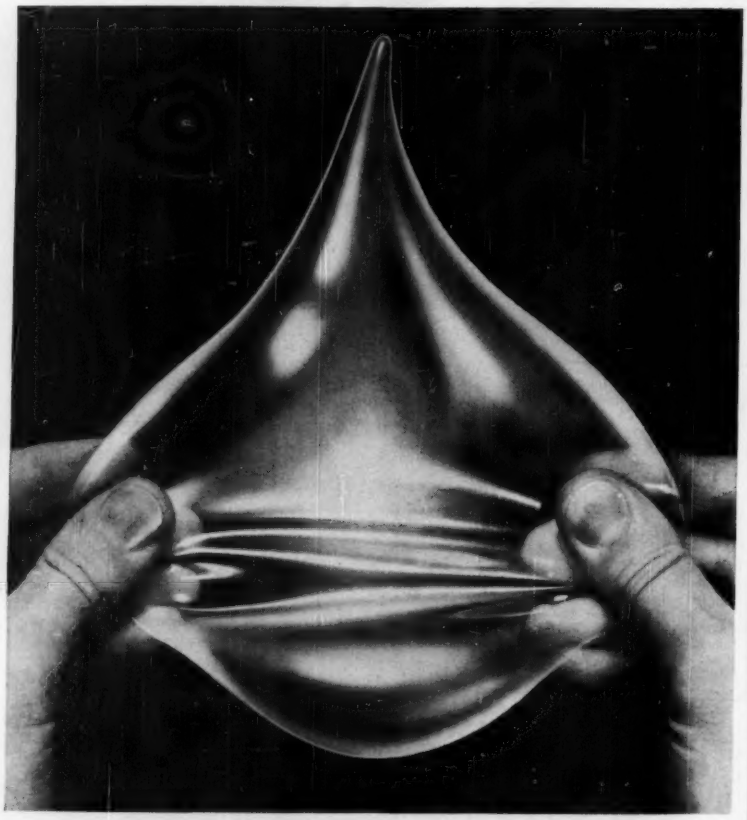

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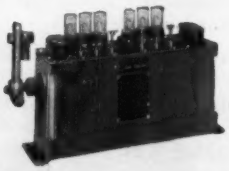

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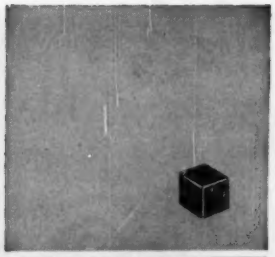

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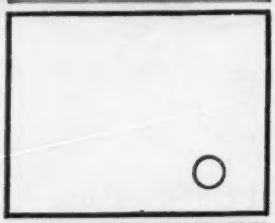

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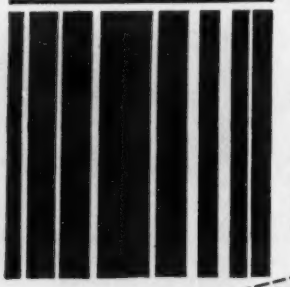

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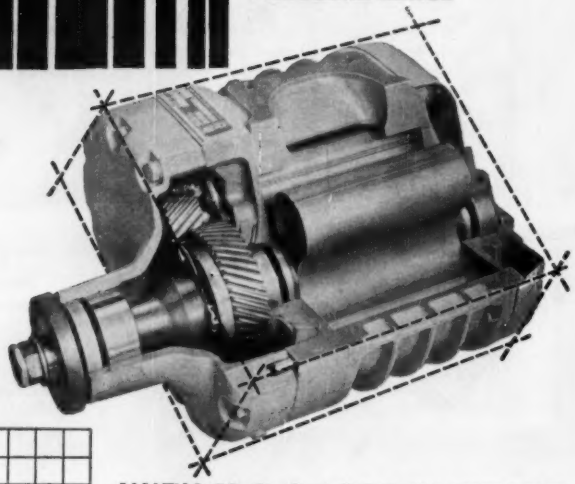

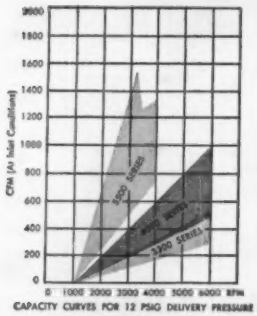

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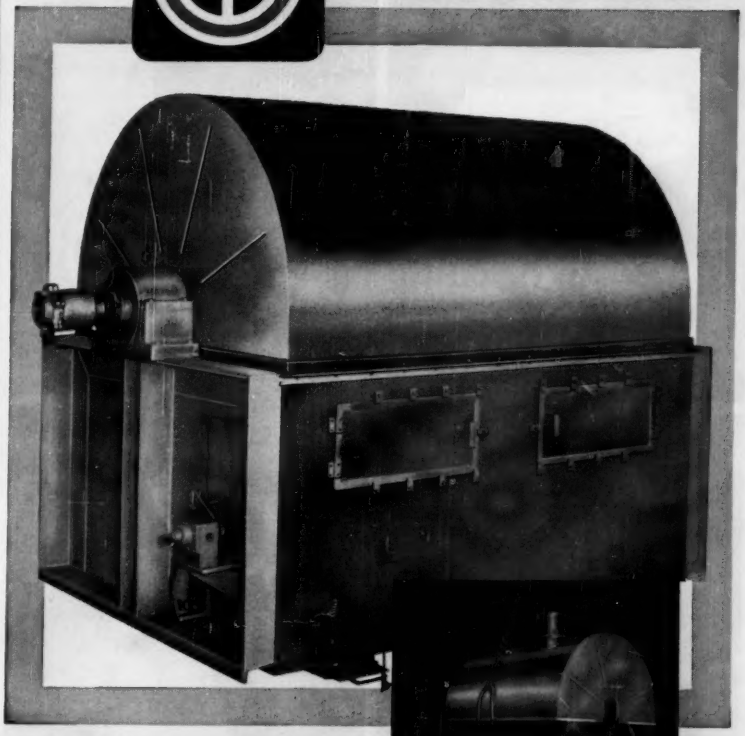

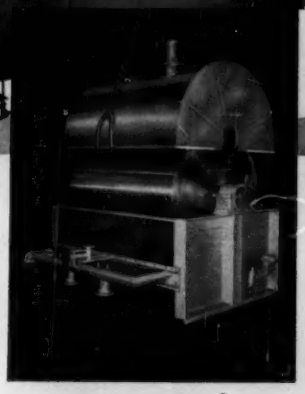

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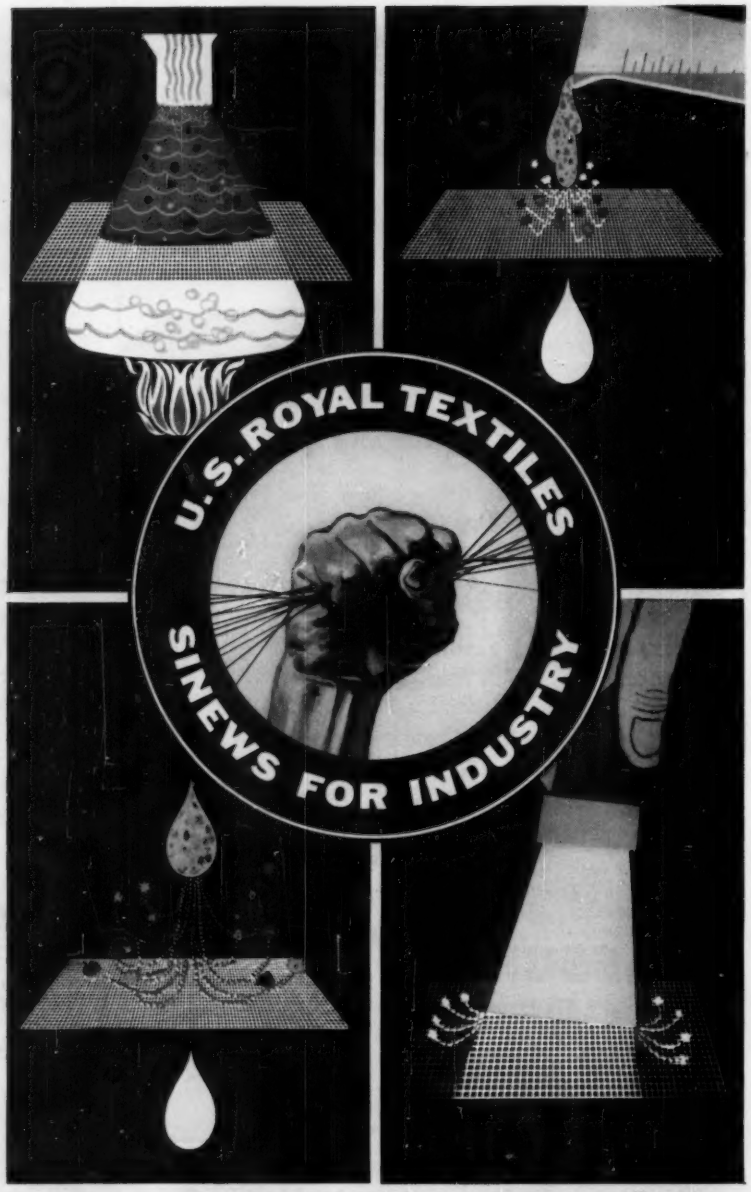

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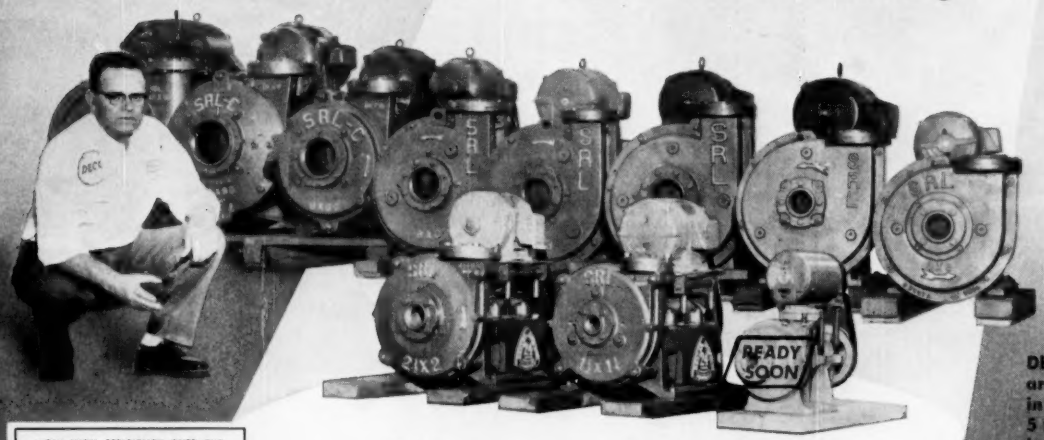

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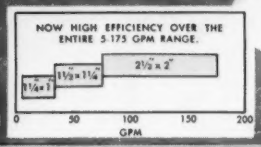

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